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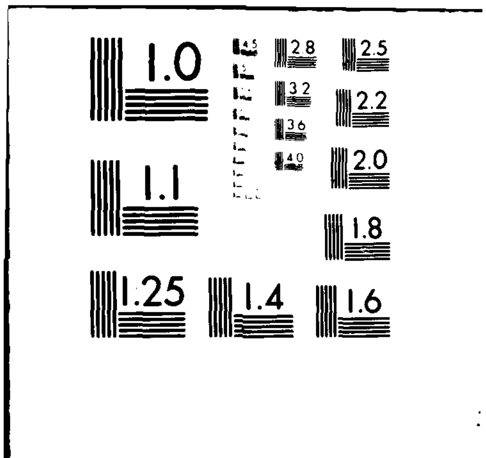

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MX SITING INVESTIGATION

GRAVITY SURVEY - DUGWAY VALLEY
UTAH

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

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19 December 1980

Revised
28 August 1981

Ertec

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: E-TR-33-DW ~~E-TR-33-DW~~	2. GOVT ACCESSION NO.: AD-A112 201
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): MX Siting Invest. Gravity Surv. Dugway Valley Utah	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER: E-TR-33-DW
7. AUTHOR(s): Ertec Western, Inc	8. CONTRACT OR GRANT NUMBER(s): F04704-80-C-0006
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Ertec Western Inc. (formerly Fugro National) P.O. Box 7765 Long Beach Ca 90807	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64312 F
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Department of the Air Force Space and Missile Systems Organization Norton AFB Ca 92409 (SAMSO)	12. REPORT DATE: Rev. 28 Aug 81
	13. NUMBER OF PAGES: ~~23~~ 45
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): –
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Distribution Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Gravity Survey, ~~[illegible]~~ Geology, Bouguer Anomaly, Depth to Rock, Valley Fill, Gravity Profile, Faults, Graben

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Results of a gravity survey of the Dugway Valley, West Central Utah indicates two distinct basins separated by a small, shallow buried ridge. The northern basin is an asymmetrical tilt block which is approximately 1800 feet deep. The southern basin is interpreted to partly enclose a north-pointed, highly fractured Tertiary volcanic complex. The gravity indicates the alluvial valley fill accumulated to a thickness of about [illegible]

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FOREWORD

Methodology and Characterization studies during Fiscal Years 1977 and 1978 (FY 77 and 78) included gravity surveys in 10 valleys; five in Arizona, two in Nevada, two in New Mexico, and one in California. The gravity data were obtained for the purpose of estimating the gross structure and shape of the basins and the thickness of the valley fill. There was also the possibility of detecting shallow rock in areas between boring locations. Generalized interpretations from these surveys were included in Ertec Western's (formerly Fugro National) Characterization Reports (FN-TR-26a through e).

During the FY 77 surveys, measurements were made on an approximate 1-mile grid over the study areas, and contour maps showing interpreted depth to bedrock were made. In FY 79, the decision was made to concentrate on verifying and refining suitable area boundaries. This decision resulted in a reduction in the gravity program. Instead of obtaining gravity data on a grid, the reduced program consisted of obtaining gravity measurements along profiles across the valleys where Verification studies were also performed.

The Defense Mapping Agency (DMA), St. Louis, Missouri, was requested to provide gravity data from their library to supplement the gravity profiles. For Big Smoky, Hot Creek, and Big Sand Springs valleys, a sufficient density of library data was available to permit construction of interpreted depth contour maps instead of just two-dimensional cross sections.

In late summer of FY 79, supplementary funds became available to begin data reduction. At that time, inner zone terrain corrections were begun on the library data and the profiles from Big Smoky Valley, Nevada, and Butler and La Posa valleys, Arizona. The profile data from Whirlwind, Hamlin, Snake East, White River, Garden, and Coal valleys, Nevada-Utah, became available from the field in early October 1979.

A continuation of gravity interpretations has been incorporated into the FY 80-81 program, and the results are being summarized in a series of valley reports. Reports covering Nevada-Utah gravity studies are numbered "E-TR-33-" followed by the abbreviation for the subject valley. In addition, more detailed reports of the results of FY 77 surveys in Dry Lake and Ralston valleys, Nevada, were prepared. Verification studies were continued in FY 80 and 81, and gravity studies were included in the program. DMA continued to obtain the field measurements, and there was a return to the grid pattern. The interpretation of the grid data allows the production of depth contour maps which are valuable in the deep basin structural analysis needed for computer modeling in the water resources program. The

gravity interpretations will also be useful in Nuclear Hardness and Survivability (NH&S) evaluations.

The basic decisions governing the gravity program are made by BMO following consultation with TRW, Inc., Ertec Western, Inc. and the DMA. The gravity studies is a joint effort between DMA and Ertec Western, Inc. The field work, including planning, logistics, surveying, and meter operation is done by the Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC), headquartered in Cheyenne, Wyoming. DMAHTC reduces the data to Simple Bouguer Anomaly (see Section A1.4, Appendix A1.0). The Defense Mapping Agency Aerospace Center (DMAAC), St. Louis, Missouri, calculates outer zone terrain corrections.

Ertec Western, Inc. provides DMA with schedules showing the valleys with the highest priorities. Ertec Western, Inc. also recommended locations for the profiles in the FY 79 studies with the provision that they should follow existing roads or trails. Any required inner zone terrain corrections are calculated by Ertec Western, Inc. prior to processing the gravity data and making geologic interpretations.

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1.0 INTRODUCTION

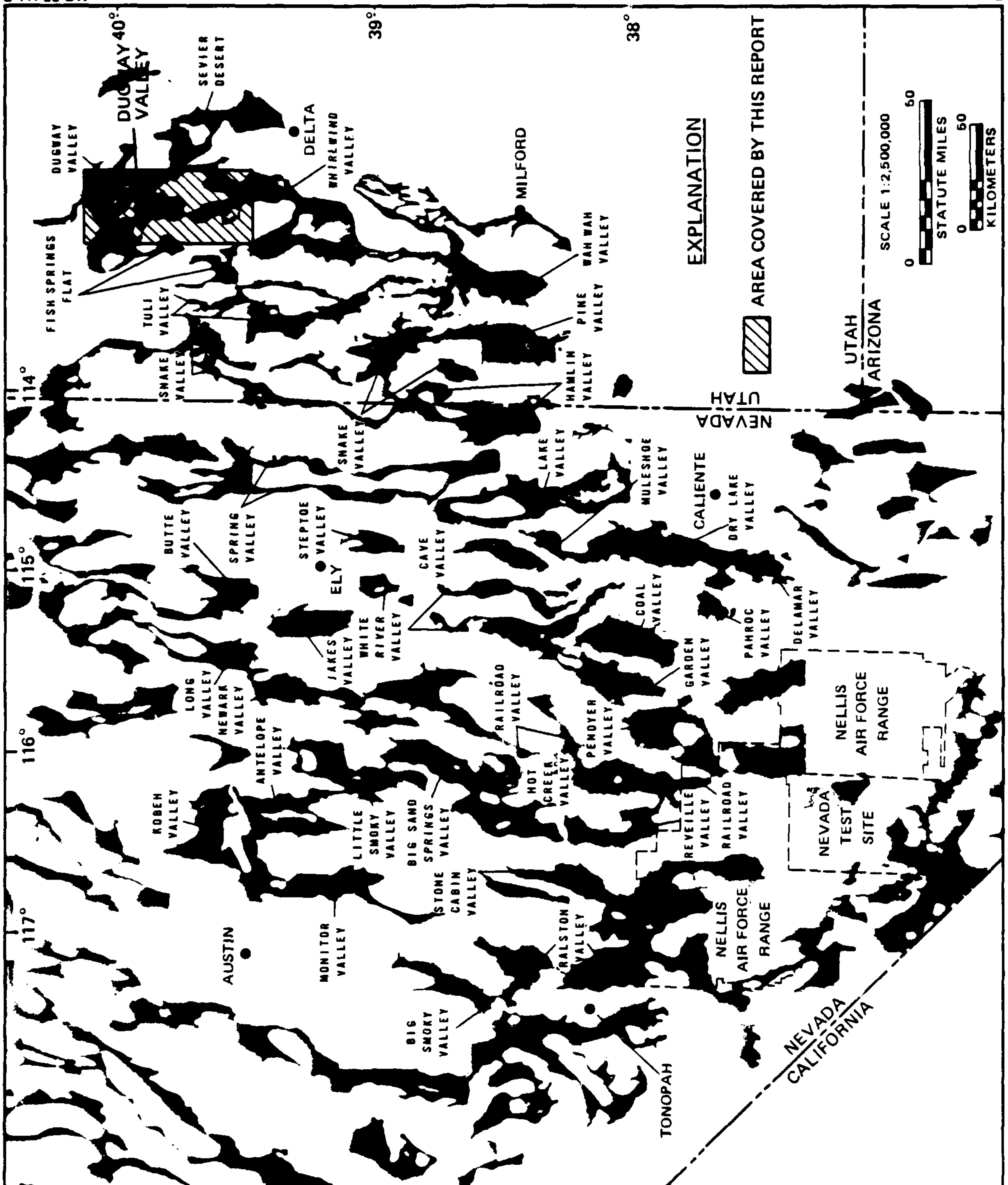
1.1 OBJECTIVE

Gravity measurements were made in Dugway Valley, Utah, for the purpose of estimating the overall shape of the structural basin, the thickness of alluvial fill, and the location of concealed faults. These estimates will be useful in modeling the dynamic response of ground motion in the basin and in evaluating ground-water resources.

1.2 LOCATION

Dugway Valley is located in Tooele and Juab counties in west-central Utah (Figure 1). The gravity survey covered the entire valley which is located approximately 80 miles (128 km) south-west of Salt Lake City, Utah. Dugway Valley lies within the area bounded by latitudes 39° 30' and 40° 05' and longitudes 112° 45' and 113° 10' (Figure 2). The valley is about 36 miles (58 km) long and 9 miles (14 km) wide. The only paved road within the site is State Highway 58 which traverses the north end of the valley.

Dugway Valley is bounded by mountain ranges on two sides, open to the Dugway Proving Ground on the north, and Sevier Desert and Whirlwind Valley on the southeast (Figure 2). The western boundary of the valley is formed by the Dugway Range in the north, Thomas Range, and the Drum Mountains in the south. Simpson Mountains, Slow Elk Hills, and Keg Mountains comprise the eastern valley border from the north to the south.



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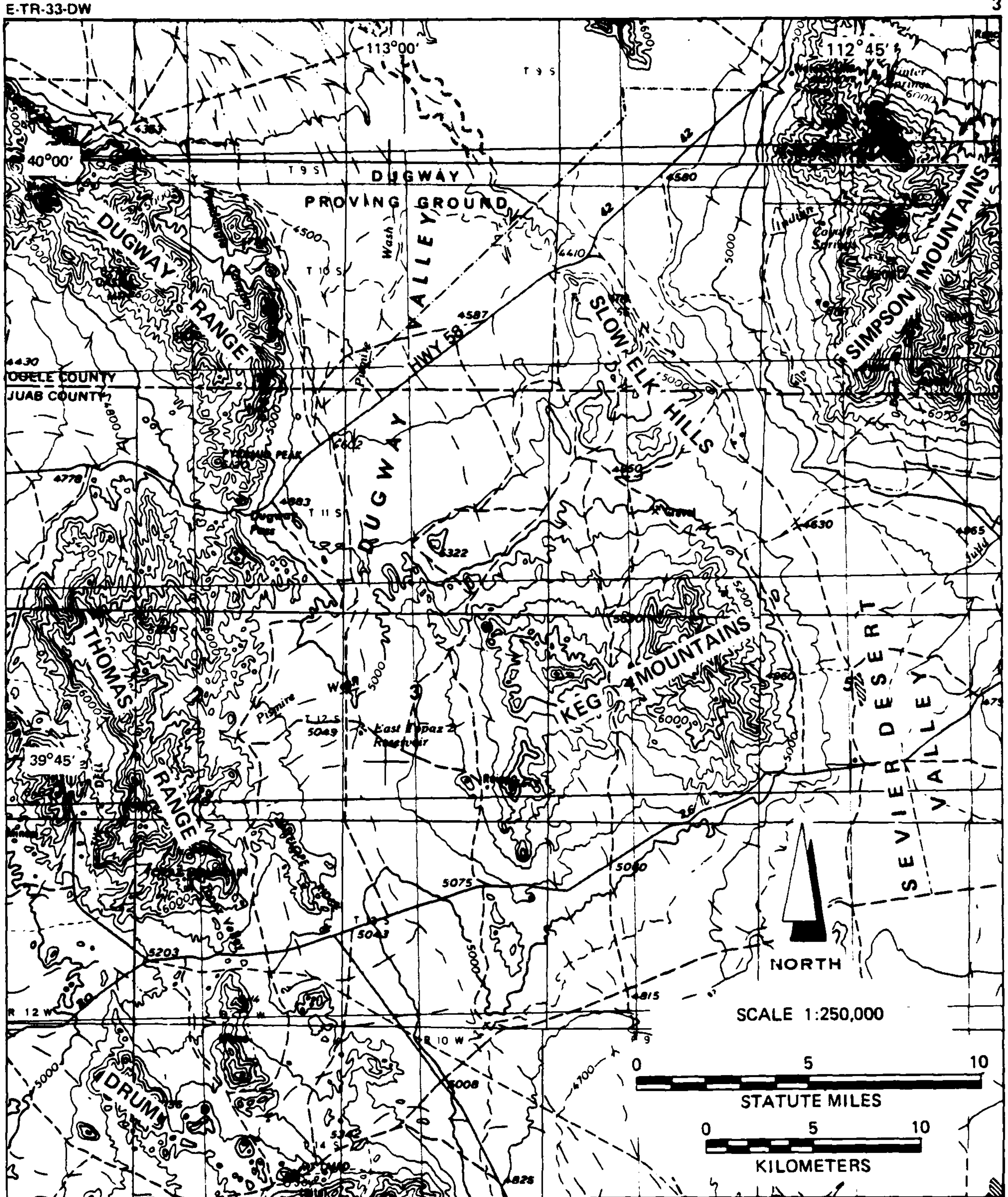
LOCATION MAP
DUGWAY VALLEY, UTAH

19 Dec 1980
28 Aug 1981 Revised

FIGURE 1



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TOPOGRAPHIC SETTING
DUGWAY VALLEY, UTAH

19 Dec 1980
28 Aug 1981 Revised

FIGURE 2

1.3 SCOPE OF WORK

Five primary work elements were completed during this study. They are:

1. Computation and merging of terrain corrections with Simple Bouguer values;
2. Synthesis of regional and valley-specific geological data;
3. Evaluation of the regional field and residual separation;
4. Inverse modeling to estimate depth to bedrock; and
5. Interpretation of structural relationships.

The gravitational field within Dugway Valley was defined by measurements from 442 stations. The gravity stations were distributed throughout the valley at intervals of about 1.3 miles (2.1 km). The principal facts for these stations are listed in Appendix A2.0, and their distribution is shown in Drawing 1. The Defense Mapping Agency Aerospace Center (DMAAC) supplied data for 56 gravity stations from its library, and 386 new gravity measurements were made by the Defense Mapping Agency Hydrographic Topographic Center/Geodetic Survey Squadron (DMAHTC/GSS).

Dugway Valley and Sevier Desert Valley were studied together with the results presented in separate reports. The region containing both valleys is located between north latitudes 39° 20' and 40° 05' and west longitudes 112° 20' and 113° 15'. There are 989 gravity stations in the region. All were used to establish a common regional gravity trend for the two valleys.

The tolerance for establishing station elevation was 5 feet (1.5m), which limits the gravity precision to 0.3 milligals.

2.0 GRAVITY DATA REDUCTION

DMAHTC/GSS obtained the basic observations for the new stations and reduced them to Simple Bouguer Anomalies (SBA) as described in Appendix A1.0. Up to three levels of terrain corrections were applied to the new stations to convert the SBA to the Complete Bouguer Anomaly (CBA). Only the first two levels of terrain corrections described below were applied to the library stations.

First, the DMAAC used its library of digitized terrain data and a computer program to calculate corrections out to 104 miles (167 km) from each station. When the program could not calculate the terrain effects near a station, Ertec Western used a ring template to estimate the effect of terrain within approximately 3000 feet (914 m) of the station. The third level of terrain corrections was applied to those stations where relief of 10 feet (3 m) or more was observed within 130 feet (40 m). In these cases, the elevation differences were measured in the field at a distance of 130 feet (40 m) along six directions from the stations. These data were used by Ertec Western to calculate the effect of the very near relief.

3.0 GEOLOGIC SUMMARY

The structural geologic setting, major rock types, and depositional regime of the valley-fill material are important considerations in the interpretation of gravitational field data.

Dugway Valley is an elongate, north-south trending, alluvial basin. Tertiary volcanic rocks crop out in the Keg Mountain, the Thomas Range, and the Drum Mountains. These rocks consist of late Tertiary silicic flows and pyroclastics and more basic early Tertiary latite flows and ash-flow tuffs (ignimbrites) (Stokes, 1963). The Dugway Range is composed of complexly folded and faulted upper-Mississippian to middle Cambrian limestone and dolomite with minor shale, sandstone, and lower Cambrian quartzite (Stokes, 1963; and Stephens and Sumsion, 1978). Similar Paleozoic sedimentary rocks crop out on the northwestern flank of the Keg Mountains and in the Slow Elk Hills (Stokes, 1963; and Stephens and Sunsion, 1978). Everywhere they have been mapped, the lower Cambrian quartzite and sandstone are in fault contact with other Paleozoic rocks.

Young fault offsets are rare in Dugway Valley. The only major group of faults is a series of semiparallel Holocene scarps east of the Drum Mountains. These features are of particular concern because they are associated with a broad zone of tectonic deformation extending about 20 miles (32 km) into the contiguous Whirlwind Valley to the south. The nature of the fault zone suggests that it probably is associated also with a concealed, major, basin-bounding fault along the western side of the Sevier

Desert. The scarps disrupt low-level Lake Bonneville shorelines (late Pleistocene and Holocene) and thus are considered Holocene in age. These faults form a series of branching scarps with the major scarps nearest the mountain front. These branching series of scarps and cracks are generally confined to alluvium but appear to involve bedrock outcrops in a few cases. Their sense of displacement varies with both the upslope and the downslope blocks being relatively uplifted. The Sevier Desert gravity data suggest that these surface scarps may represent more than one major subsurface fault. Vertical separations range from about 2 to 24 feet (0.6 to 7.3 m) (Bucknam and Anderson, 1979).

Dugway Valley is underlain by a thick accumulation of Miocene to Holocene valley-fill deposits. The older deposits consist of sandstone, shale, limestone, basalt, evaporites, conglomerate, and tuff. The younger surficial deposits consist of alluvial fan and lacustrine deposits. The lacustrine deposits are composed of uncemented lake sediments and shoreline berms and bars left by the Pleistocene Lake Bonneville. They are predominantly silt and silty sand with lesser amounts of gravelly sand and clay. The alluvial fan deposits range from silty sand to gravelly sand and are uncemented to weakly cemented. These deposits are derived from erosion of the surrounding mountains.

4.0 INTERPRETATION

A density contrast exists between a valley filled with lightweight alluvium and the denser surrounding bedrock. This density contrast creates a negative gravity anomaly. Interpretation of the gravity data first requires the removal of the regional gravity trends from the total gravitational field measured at the surface. Once isolated, the negative gravity anomaly, which is the gravity reflection of the valley-fill material, can be used to estimate the depth of bedrock.

The gravity stations are distributed over a quasi-grid, giving a fairly uniform coverage but somewhat irregular spacing. To facilitate the mathematical treatment of irregularly spaced data, the CBA and elevation data are reduced to a set of values at the nodes of a uniformly spaced geographic array or grid. The gridding process is an iterative one which uses an algorithm that computes a value at each node by finding a surface that is both biharmonic and fits the gravity station data. A 1.2-mile (2-km) grid spacing was chosen to match the average data spacing. Drawing 1 shows the CBA gravity field contoured from gridded values and the location of the gravity stations.

4.1 REGIONAL-RESIDUAL SEPARATION

A fundamental step in gravity interpretation is isolation of the part of the CBA which represents the geologic feature of interest, in this case, the valley fill. The portion of the CBA which corresponds to this material is called the "residual anomaly."

The CBA contains long wavelength components from deep and broad geologic structures extending far beyond the valley. These components, called the regional gravity, were approximated by a second-degree trend surface which was derived from several upward continuation models. The residual anomaly was obtained by subtracting the regional gravity from the CBA values. The residual anomaly was appropriately adjusted by a constant -5.0 milligals to agree with the soil-rock contact and then used to calculate a simple geologic model which fits the gravity data and is consistent with geologic knowledge from other sources.

4.2 DENSITY SELECTION

The construction of a geologic model from the residual anomaly requires selection of density values representative of the fill material and of the underlying rock. Average in situ density of the alluvium was measured between depths of 140 to 160 feet (43 to 49 m) in five shallow borings drilled in Dugway Valley during Verification studies (Ertec, unpublished). The observed density range for the alluvium was 1.7 to 2.2 g/cm^3.

Based on the geologic characteristics of the surrounding mountains, middle Tertiary volcanic rocks probably lie between the alluvial basin deposits and the carbonate basement in Dugway Valley, but little is known about their thickness and density. The density of siliceous to intermediate volcanic rocks generally ranges between 2.0 to 2.5 g/cm^3 depending on the degree of welding, compaction, and alteration. The older volcanics in the Dugway Valley area are probably at the higher end of this

density range, being approximately equivalent to dense alluvium or between the density of alluvium and the density of bedrock. The information available regarding the volume and characteristics of the subsurface volcanic rocks is insufficient to calculate their quantitative effect on the gravitational field. Therefore, a density of 2.4 g/cm^3 was used in the modeling process to estimate the effect of the combined alluvium and volcanic material.

The bedrock underlying the Dugway basin is thought to be Paleozoic carbonate rocks such as those found in limited outcrops in the surrounding mountain ranges. Published values for carbonate rocks typically range betwen 2.6 and 2.9 g/cm^3. The Paleozoic carbonate rocks in Nevada and Utah are generally reported to be relatively high in density, on the order of 2.8 g/cm^3. This value was selected to represent the density of the bedrock. The density contrast between the carbonate rocks and the valley fill materials used in modeling was -0.40 g/cm^3.

For a given bedrock density, the calculated basin depth is inversely proportional to the density value assigned to the valley-fill materials. A one percent change in the average fill material density will result in a six percent change in the calculated fill thickness. Because only very generalized density information is available, the geologic interpretation of the gravity data can be only a coarse approximation.

4.3 MODELING

Modeling was done with the aid of a computer program which iteratively calculates a three-dimensional solution of gravity anomaly data (Cordell, 1970). The gravity anomaly is represented by discrete values on a two-dimensional grid. The source of the anomaly (the volume of low-density valley fill) is represented by a set of vertical prism elements. The tops of the prisms lie in a common horizontal plane. The bottoms of the prisms collectively represent the bottom of the valley fill. Each prism has a uniform density and cross-sectional area equal to one grid square. A grid of 1.2 miles by 1.2 miles (2 km by 2 km) was selected as representative of the gravity station distribution. Computations were made for nine iterations of mutually interactive prism adjustments. The root-mean-square error between the observed residual gravity field and the field calculated for the final geologic model of the valley was less than 0.3 milligal.

The calculated thickness of the valley fill depends upon the residual anomaly and the density contrast. Since neither density is perfectly known nor even uniform, the calculated thickness should be expected to contain a corresponding degree of uncertainty. Geotechnical data obtained by Ertec Western from 20 shallow borings and 24 seismic refraction lines in Dugway Valley were used as constraints in the interpretation. Three borings encountered volcanic material at shallow depth, but no velocity high enough to indicate rock was recorded by the refraction lines.

In addition to the geotechnical data, results from five exploration borings listed for the valley in the literature and two oil wells in southern Sevier Desert Valley were used as modeling constraints (Table 1). The two oil wells placed a major restraint on the interpretation of Sevier Desert Valley, and thus had an indirect influence on this contiguous valley. The calculated thickness of valley fill material, or interpreted depth to rock, is contoured in Drawing 2.

The analysis of the gravity data included calculation of the second vertical derivative (SVD) of the CBA field. One property of the SVD is that its zero value marks the steepest gradients of the input CBA field. In this Basin and Range valley, steep gravity gradients are interpreted as being caused by bedrock fault systems. The SVD is used to guide the placement of faults in the structural interpretation. The interpreted faults represent only the major fault systems which probably comprise many smaller fault zones. There may be other discrete faults that had a minor role in basin formation but with displacements so small that they were not resolved by the widely spaced gravity data available for this study.

A source of error in modeling Dugway Valley as just a simple valley-fill material and bedrock system is the widespread volcanic material which is probably present throughout the valley as indicated by a major northeast trending magnetic high traversing the center of the valley (Zietz and others, 1976). Magnetic highs typically overlie intrusive igneous rocks and indicate their extent, but there is no quantitative information

BORING RESULTS FROM LITERATURE		
BORING ID.	HOLE DEPTH FEET / (METERS)	REMARKS
ANACONDA NO. 1	580 / (177)	VOLCANICS
ANACONDA NO. 2	530 / (162)	VOLCANICS
C-10-10-1	375 / (114)	NO ROCK ENCOUNTERED
C-11-11	306 / (93)	NO ROCK ENCOUNTERED
15-10-1	701 / (214)	VOLCANICS
GULF OIL GRONNING * NO. 1	8061 / (2457)	VOLCANICS
ARGONAUT FEDERAL * ENERGY NO. 1	11266 / (3434)	TOP OF CARBONATE ROCKS AT 7702 FT. (2342m)

BORING LOCATIONS SHOWN ON DRAWING 2.

* OIL WELLS IN SEVIER DESERT VALLEY

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BORING RESULTS
DUGWAY VALLEY, UTAH

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TABLE 1

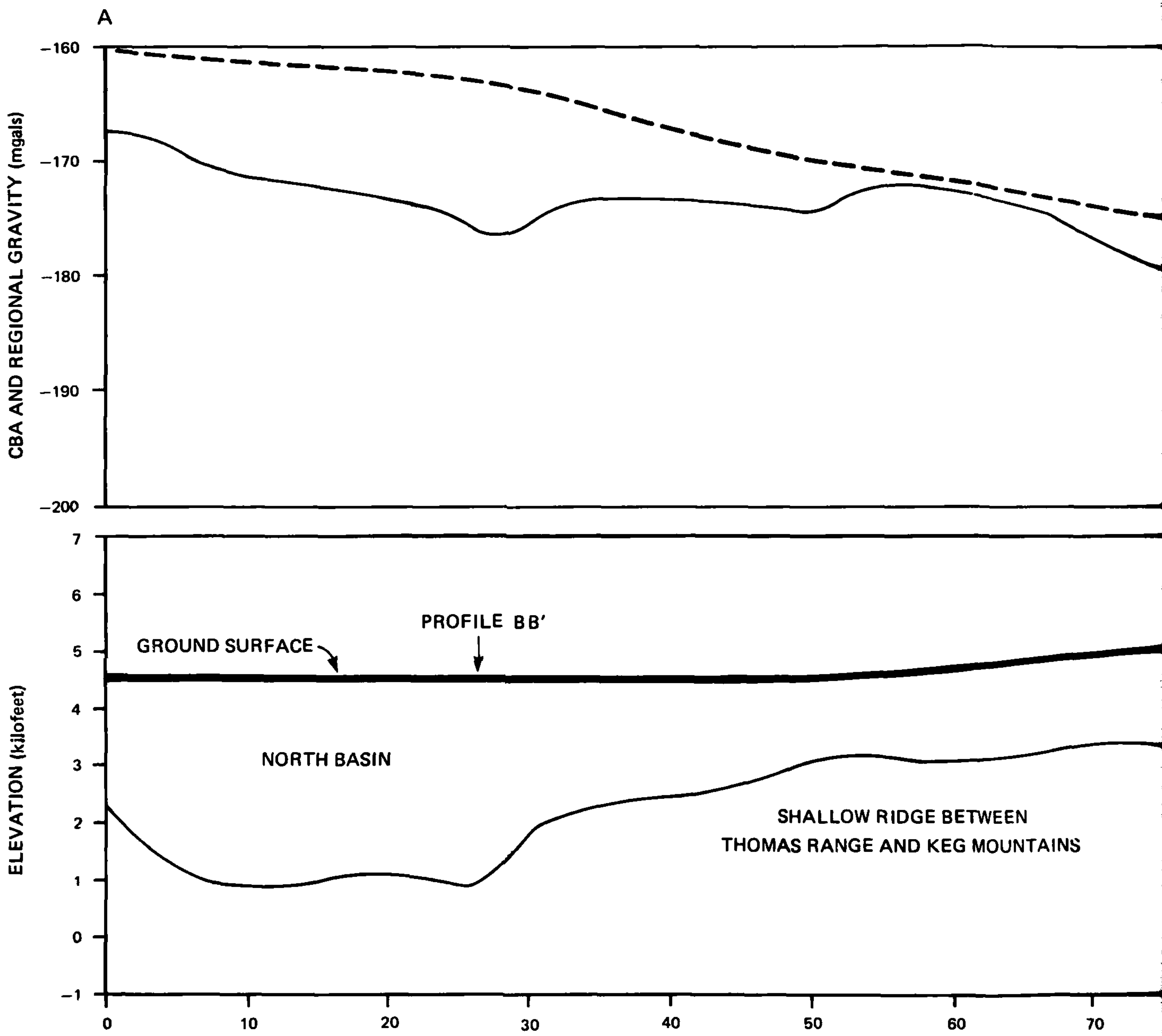
available about the density or volume of the volcanic material. Therefore, the effect of the volcanics on the gravitational field can be only estimated.

4.4 DISCUSSION OF RESULTS

The interpreted geologic structure of Dugway Valley is shown on the depth-to-rock contour map (Drawing 2). The interpretation is based on geologic information from published reports, analysis of aerial photographs, and geologic field reconnaissance as well as gravity data.

Dugway Valley is composed of two narrow, complex, structural basins which contain several major bedrock faults. The north-south profile AA' (Figure 3) shows an 1800-foot (549-m) vertical offset between the northern graben block and the deeper graben in the south. The northern basin is oriented N-S and the southern basin trends NNW.

The northern basin is an asymmetrical tilted block which dips down toward the west and has an average depth of about 3500 feet (1067 m). Cross-sectional profile BB' which crosses the shallower, northern part of the valley is shown in Figure 4. The steep gravity gradient on the west suggests a major north-south normal fault system along the base of the Dugway Range which is typical of the Basin and Range area. This interpreted boundary fault is located less than 1 mile (1.6 km) east (basinward) of the Dugway Range. The northwest corner of this basin contains a shallow pediment, less than 1000 feet (305 m) deep, which extends about 2 miles (3.2 km) from the Dugway Range into the valley (Drawing 2).



EXPLANATION

TOP: REGIONAL GRAVITY

COMPLETE BOUGUER ANOMALY (INTERPOLATED)

GRAVITY INFERRED FAULT LOCATIONS

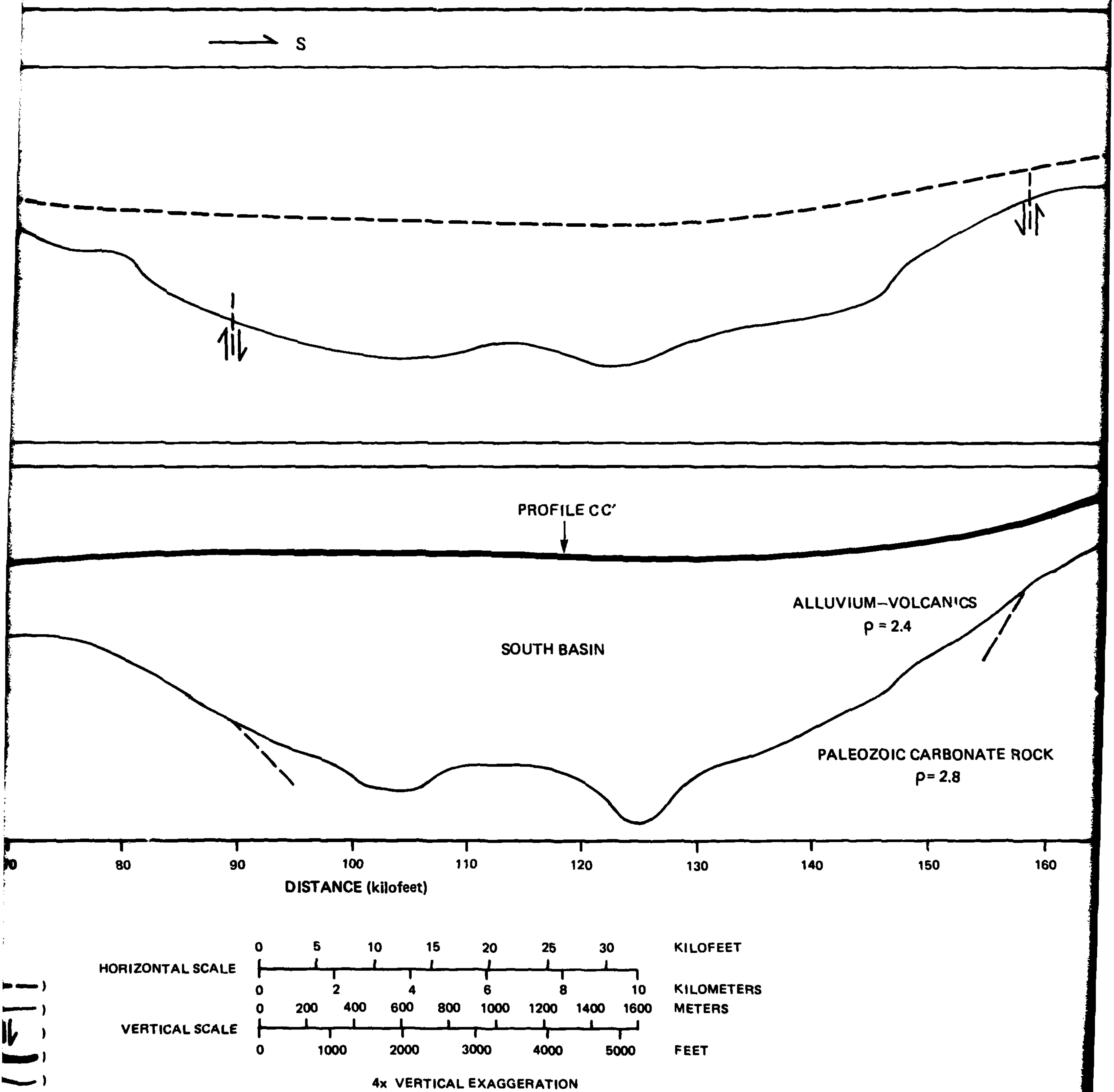
BOTTOM: INTERPOLATED SURFACE ELEVATION

MODEL OF BEDROCK SURFACE

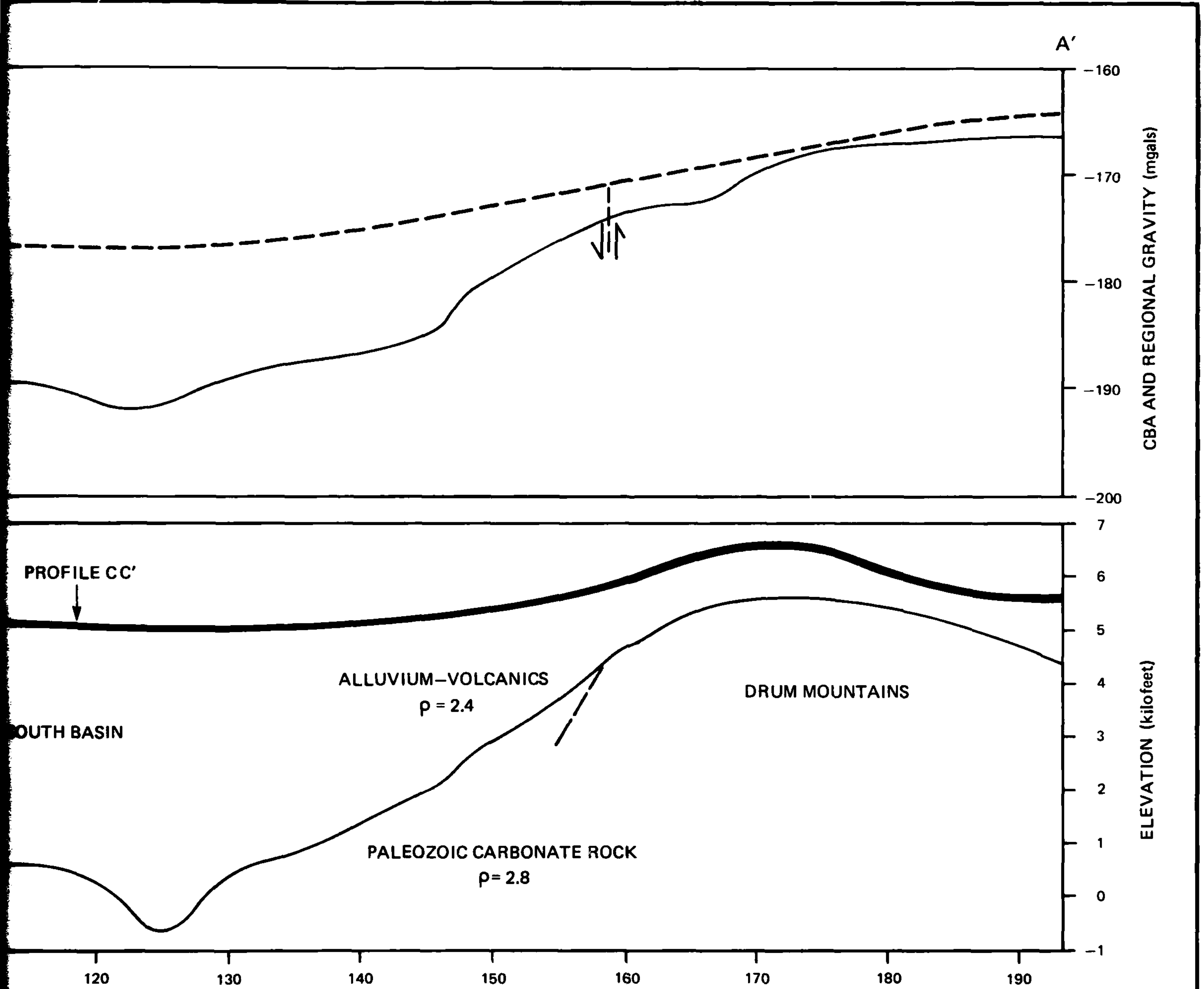
DISTANCE SCALE 1:125,000

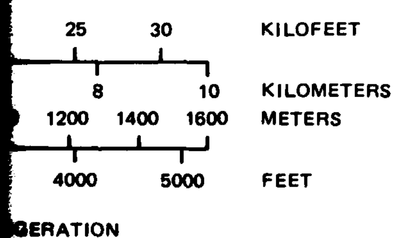
DENSITY VALUES (p = 2.4)g/cm3

2



S
PROFILE CC′
ALLUVIUM–VOLCANICS
ρ = 2.4
SOUTH BASIN
PALEOZOIC CARBONATE ROCK
ρ= 2.8
70
80
90
100
110
120
130
140
150
160
DISTANCE (kilofeet)
HORIZONTAL SCALE
0 5 10 15 20 25 30 KILOFEET
0 2 4 6 8 10 KILOMETERS
VERTICAL SCALE
0 200 400 600 800 1000 1200 1400 1600 METERS
0 1000 2000 3000 4000 5000 FEET
4x VERTICAL EXAGGERATION





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GRAVITY PROFILE A A'
CROSS SECTIONAL VIEW
DUGWAY VALLEY, UTAH

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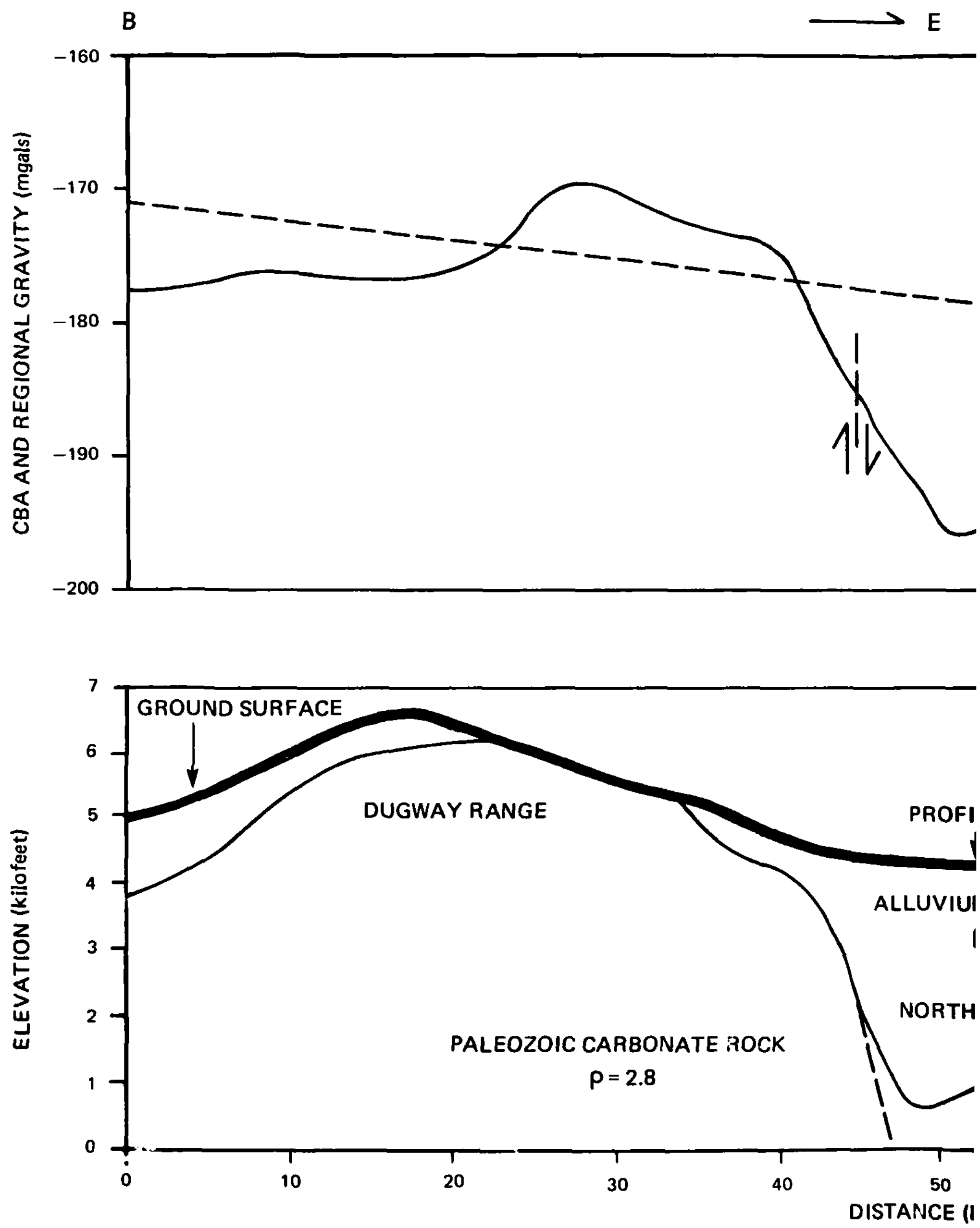
FIGURE 3



EXPLANATION

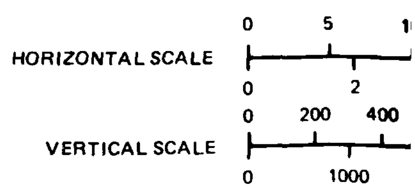
TOP: REGIONAL GRAVITY

COMPLETE BOUGUER ANOMALY (INTERPOLATED)

GRAVITY INFERRED FAULT LOCATIONS

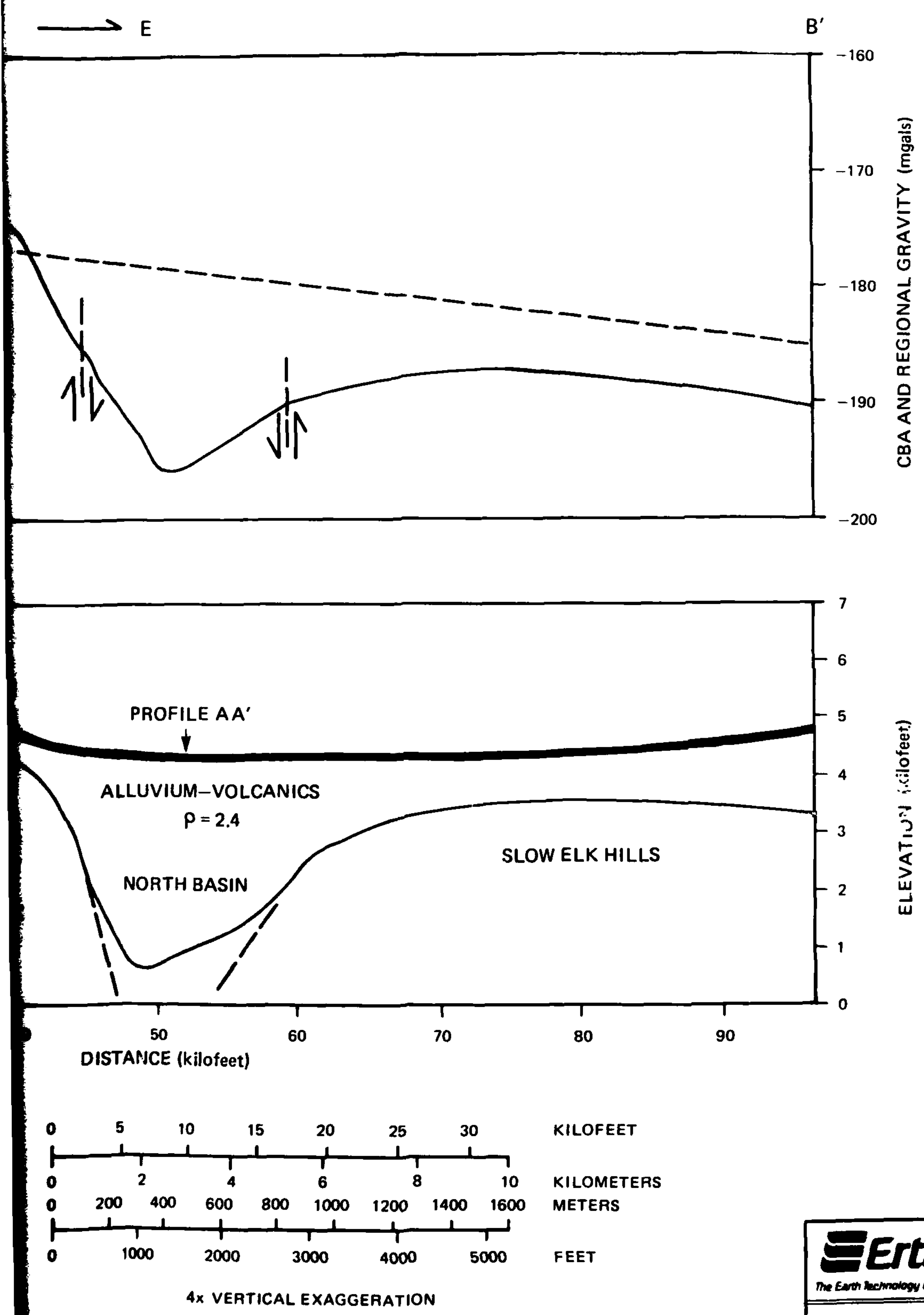
BOTTOM: INTERPOLATED SURFACE ELEVATION

MODEL OF BEDROCK SURFAC



DISTANCE SCALE 1:125,000

DENSITY VALUES (ρ · 2.4)g/cm3



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GRAVITY PROFILE B B′
CROSS SECTIONAL VIEW
DUGWAY VALLEY, UTAH

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FIGURE 4

The transition zone between the northern and southern basins appears to be a small buried ridge of volcanic material underlain by carbonate rock (Figure 3). The ridge is located about 1500 feet (457 m) below the surface and is 6 miles (9.6 km) wide. The ridge is bounded on the south by a transverse fault. This fault is the northern boundary of the southern graben block.

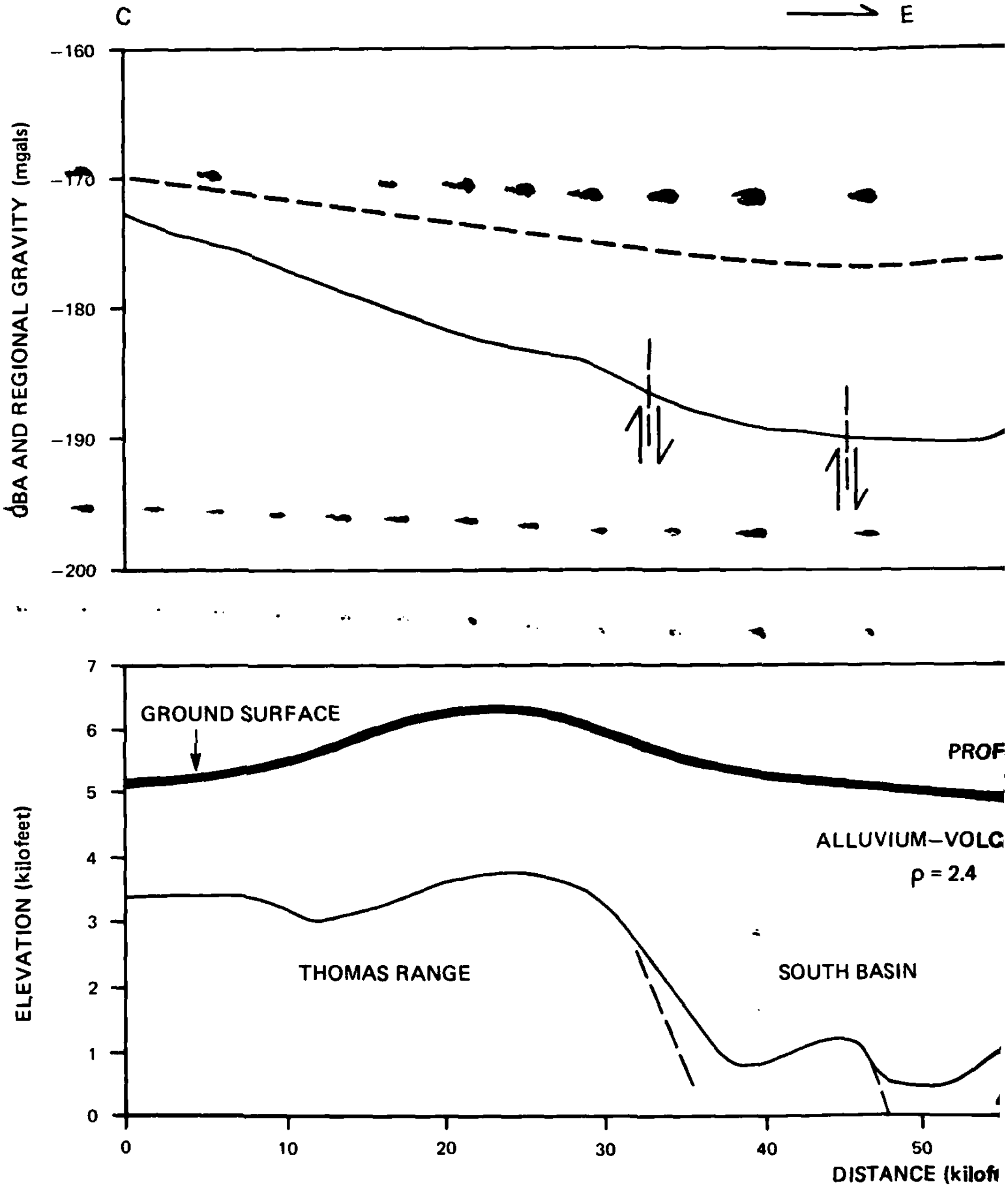
Unlike gravity results from most valleys in the Basin and Range area, the gravity data from Dugway Valley do not directly reflect the most recent Basin and Range Block faulting episode. The gravity field shows Paleozoic carbonate bedrock to be very shallow in the Dugway Range, Keg Mountains, and the Drum Mountains. The Thomas Range is apparently composed of up to 8000 feet (2438 m) of complexly faulted, low density volcanic rocks. The gravity lows at the north end of the Thomas Range and at the extreme south end of Dugway Valley are interpreted as being related to Tertiary caldera structures. The gravity low between the Dugway and Thomas ranges is interpreted to be bounded on at least three sides by ancient normal faults and to be part of a larger caldera which has been broken up by subsequent Basin and Range block faulting. The Tertiary volcanic material in this area is very thick and highly fractured.

Faults along the north side of the Drum Mountains appear to form part of the boundary of another caldera structure. The volcanic material, which is predominant in this area, appears to occupy an ancient, deep, highly faulted trough between the Dugway Range

on the north and the Drum Mountains on the south. The trough originally formed under a previous tectonic regime. This interpretation is supported by regional geologic studies and mining activities which indicate a Tertiary caldera in the Thomas Range. The fault-bounded trough appears to be oriented northwesterly and is transected by north-south trending faults which form the western boundary of the Keg Mountains (Figure 5). The northerly trending faults probably represent later Basin and Range tensional tectonic activity.

Another major fault system extends northward from the east side of the Drum Mountains to the eastern side of the Keg Mountains forming the eastern edge of a horst structure which is probably a southward subsurface extension of the Keg Mountains (Figure 5). This buried ridge is about 2000 feet (610 m) deep and separates the southern basin of Dugway Valley from the Sevier Desert Valley basin. The fault system displaces the lake shorelines and sediments in Sevier Desert Valley and hence has been active in late Pleistocene, probably Holocene, time.

The lack of widespread surface evidence for Quaternary faulting in Dugway Valley is probably due to the area being covered by lake deposits left by Lake Bonneville which occupied most of the valley during latest Pleistocene and early Holocene time. Consequently, any older alluvial fault scarps, even late Quaternary basin-bounding scarps, have been obliterated by the erosional and depositional processes associated with this great lake.



EXPLANATION

TOP: REGIONAL GRAVITY

COMPLETE BOUGUER ANOMALY (INTERPOLATED)

GRAVITY INFERRED FAULT LOCATIONS

BOTTOM: INTERPOLATED SURFACE ELEVATION

MODEL OF BEDROCK SURFACE

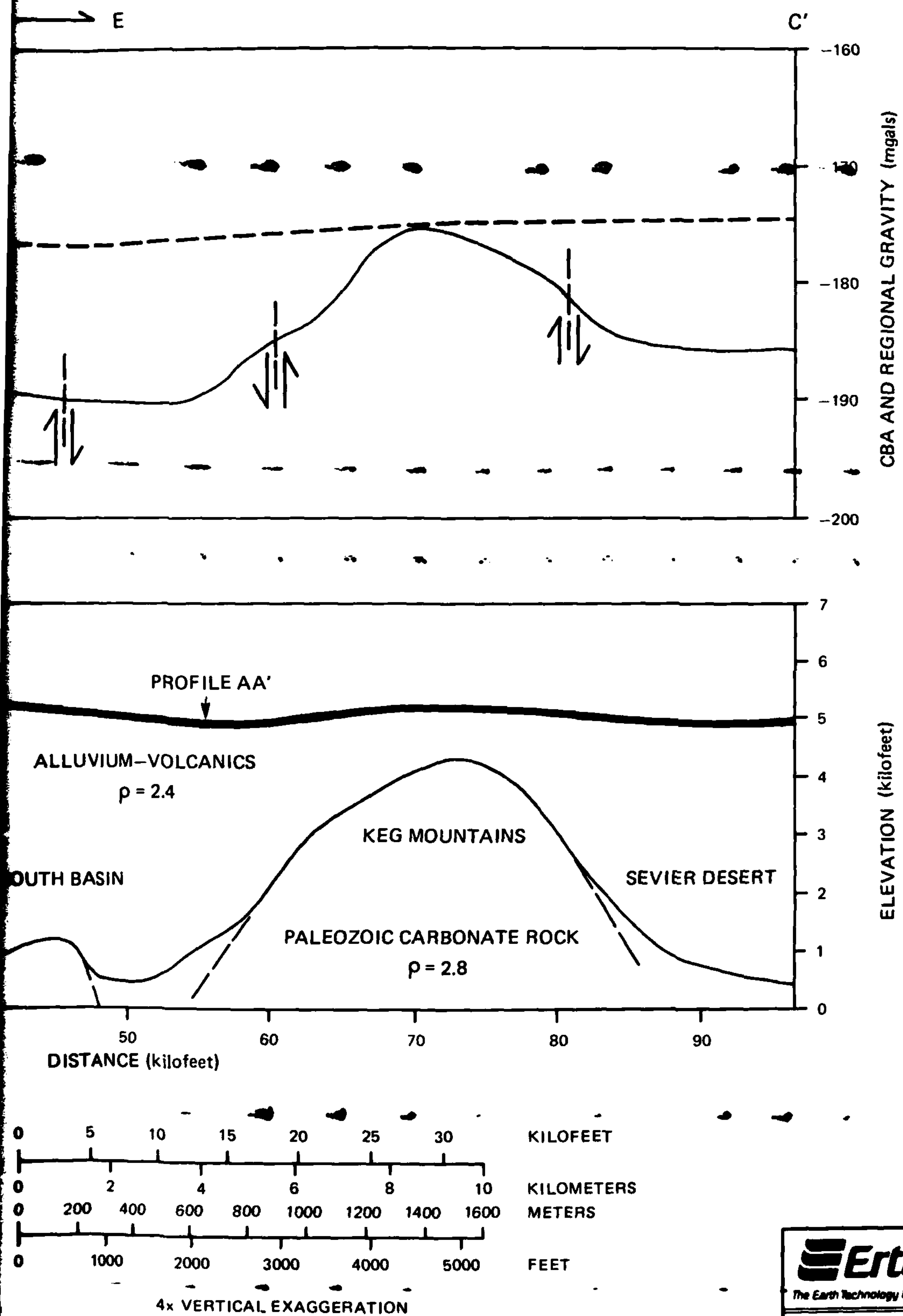
HORIZONTAL SCALE 0 5 10 / 0 2

VERTICAL SCALE 0 200 400 60 / 0 1000 20

4x V

DISTANCE SCALE 1:125,000

DENSITY VALUES (ρ = 2.4)g/cm3



Ertec
The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

GRAVITY PROFILE C C'
CROSS SECTIONAL VIEW
DUGWAY VALLEY, UTAH

19 DEC 1980
28 AUG 1981 REVISED

FIGURE 5

5.0 CONCLUSIONS

The interpretation of the gravity survey in Dugway Valley indicates two distinct basins separated by a small, shallow, buried ridge. The northern basin is an asymmetrical tilt block which is approximately 1800 feet (549 m) deep. The block is bounded on the west by a major north-south normal fault system near the base of the Dugway Range.

The southern basin is interpreted to partly comprise a collapsed, highly fractured, Tertiary caldera complex. The gravity indicates the caldera volcanics are accumulated to a thickness of about 3500 feet (1067 m) thick in a northwesterly trending trough. This caldera complex is transected by later Basin and Range, north-south trending faults systems. A narrow bedrock ridge or horst extends south from the Keg Mountains at a depth of about 2000 feet (610 m). This ridge could restrict groundwater movement between southern Dugway Valley and Sevier Desert Valley.

An average density contrast of -0.40 g/cm^3 between the alluvium-volcanic fill material and the Paleozoic carbonate bedrock was used to calculate the valley depth.

Future studies that acquire better density data, information concerning the areal extent and thickness of the Tertiary volcanic material, or actual depths to bedrock in the deep parts of the valley can be used to refine the geologic model.

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APPENDIX A1.0

GENERAL PRINCIPLES OF THE GRAVITY EXPLORATION METHOD

A1.0 GENERAL PRINCIPLES OF THE GRAVITY EXPLORATION METHOD

A1.1 GENERAL

A gravity survey involves measuring the differences in the gravitational field between various points on the earth's surface. The gravity values are associated with the force which causes a 1 gm mass to be accelerated at 980 cm/sec^2. This force is normally referred to as a 1 g force.

Even though in many applications the gravitational field at the earth's surface is assumed to be constant, small but distinguishable differences in gravity occur from point to point. The differences in gravity are caused by geometrical effects, such as differences in elevation and latitude, and by lateral variations in density within the earth. The lateral density variations are a result of changes in geologic conditions. For measurements at the surface of the earth, the largest factor influencing the pull of gravity is the density of all materials between the center of the earth and the point of measurement.

To detect changes produced by differing geological conditions, it is necessary to detect differences in the gravitational field as small as a few milligals. (A milligal is equal to 0.001 cm/sec^2 or 0.00000102 g). To recognize changes due to geological conditions, the measurements are "corrected" to account for changes due to differences in elevation and latitude. A difference in gravity between two points which is not caused by the effects of known geometrical differences, such as in elevation,

latitude, and surrounding terrain, is referred to as an "anomaly." The anomaly is the basic concept of the gravitational exploration method. If, instead of being an oblate spheroid characterized by complex density variations, the earth were made up of concentric, homogeneous shells, the gravitational field would be the same at all points on the surface of the earth. The complexities in the earth's shape and material distribution are the reason that the pull of gravity is not the same from place to place.

An anomaly reflects lateral differences in material densities. The gravitational attraction is smaller at a place underlain by relatively low density material than it is at a place underlain by a relatively high density material. The term "negative gravity anomaly" describes a situation in which the pull of gravity within a prescribed area is small compared to the area surrounding it. Low-density alluvial deposits in basins such as those in the Nevada-Utah region produce negative gravity anomalies in relation to the gravity values in the surrounding mountains which are formed by more dense rocks.

The objective of gravity exploration is to deduce the variations in geologic conditions that produce the gravity anomalies identified during a gravity survey.

A1.2 INSTRUMENTS

The gravity field data was measured with a LaCoste and Romberg Model D gravimeter. The sensing element of the gravimeter is a mass suspended by a zero-length spring. Deflections of the

mass from a null position are proportional to changes in gravitational attraction. These instruments are sealed and compensated for atmospheric pressure changes. They are maintained at a constant temperature by an internal heater element and thermostat. The absolute value of gravity is not measured directly by a gravimeter. It measures relative values of gravity between one point and the next. Gravitational differences as small as 0.01 milligal can be measured.

A1.3 FIELD PROCEDURES

The gravimeter readings were calibrated in terms of absolute gravity by taking readings twice daily at nearby USGS gravity base stations. Gravimeter readings fluctuate because of small time-related deviations due to the effect of earth tides and instrument drift. Field readings were corrected to account for these deviations. The magnitude of the tidal correction was calculated using an equation suggested by Goguel (1954):

$$C = P + N\cos\phi\,(\cos\phi + \sin\phi) + S\cos\phi\,(\cos\phi - \sin\phi)$$

where C is the tidal correction factor, P, N, and S are time-related variables, and ϕ is the latitude of the observation point. Tables giving the values of P, N, and S are published annually by the European Association of Exploration Geophysicists.

The meter drift correction was based on readings taken at a designated base station at the start and end of each day. Any difference between these two readings after they were corrected for tidal effects was considered to have been the result of

instrumental drift. It was assumed that this drift occurred at a uniform rate between the two readings. Corrections for drift were typically only a few hundredths of a milligal. Readings corrected for tidal effects and instrumental drift represented the observed gravity at each station. The observed gravity values represent the total gravitational pull of the entire earth at the measurement stations.

A1.4 DATA REDUCTION

Several corrections or reductions are made to the observed gravity to isolate the portion of the gravitational pull which is due to the crustal and near-surface materials. The gravity remaining after these reductions is called the "Bouguer Anomaly." Bouguer Anomaly values are the basis for geologic interpretation. To obtain the Bouguer Anomaly, the observed gravity is adjusted to the value it would have had if it had been measured at the geoid, a theoretically defined surface which approximates the surface of mean sea level. The difference between the "adjusted" observed gravity and the gravity at the geoid calculated for a theoretically homogeneous earth is the Bouguer Anomaly.

Four separate reductions, to account for four geometrical effects, are made to the observed gravity at each station to arrive at its Bouguer Anomaly value.

a. Free-Air Effect: Gravitational attraction varies inversely as the square of the distance from the center of the earth. Thus corrections must be applied for elevation. Observed

gravity levels are corrected for elevation using the normal vertical gradient of:

$$FA = -0.09406 \text{ mg/ft } (-0.3086 \text{ milligals/meter})$$

where FA is the free-air effect (the rate of change of gravity with distance from the center of the earth). The free-air correction is positive in sign since the correction is opposite the effect.

b. Bouguer Effect: Like the free-air effect, the Bouguer effect is a function of the elevation of the station, but it considers the influence of a slab of earth materials between the observation point on the surface of the earth and the corresponding point on the geoid (sea level). Normal practice, which is to assume that the density of the slab is 2.67 grams per cubic centimeter was followed in these studies. The Bouguer correction (B_c), which is opposite in sign to the free-air correction, was defined according to the following formula.

$$B_c = 0.01276 \ (2.67) \ h_f \ \text{(milligals per foot)}$$

$$B_c = 0.04185 \ (2.67) \ h_m \ \text{(milligals per meter)}$$

where h_f is the height above sea level in feet and h_m is the height in meters.

c. Latitude Effect: Points at different latitudes will have different "gravities" for two reasons. The earth (and the geoid) is spheroidal, or flattened at the poles. Since points at higher latitudes are closer to the center of the earth than points near the equator, the gravity at the higher latitudes is larger. As the earth spins, the centrifugal acceleration

causes a slight decrease in the measured gravity. At the higher latitudes where the earth's circles of latitude are smaller, the centrifugal acceleration diminishes. The gravity formula for the Geodetic Reference System, 1967, gives the theoretical value of gravity at the geoid as a function of latitude. It is:

$$g = 978.0381\ (1 + 0.0053204\ \sin^2 \phi - 0.0000058\ \sin^2 2\phi)\ \text{gals}$$

where g is the theoretical acceleration of gravity and ϕ is the latitude in degrees. The positive term accounts for the spheroidal shape of the earth. The negative term adjusts for the centrifugal acceleration.

The previous two corrections (free air and Bouguer) have adjusted the observed gravity to the value it would have had at the geoid (sea level). The theoretical value at the geoid for the latitude of the station is then subtracted from the adjusted observed gravity. The remainder is called the Simple Bouguer Anomaly (SBA). Most of this gravity represents the effect of material beneath the station, but part of it may be due to irregularities in terrain (upper part of the Bouguer slab) away from the station.

d. Terrain Effect: Topographic relief around the station has a negative effect on the gravitational force at the station. A nearby hill has upward gravitational pull and a nearby valley contributes less downward attraction than a nearby material would have. Therefore, the corrections are always positive. Corrections are made to the SBA when the terrain effects were 0.01 milligal or larger. Terrain corrected Bouguer values are

called the Complete Bouguer Anomaly (CBA). When the CBA is obtained, the reduction of gravity at individual measurement points (stations) is complete.

A1.5 INTERPRETATION

To interpret the gravity data, the portion of the CBA that might be caused by the light-weight, basin-fill material must be separated from that caused by the heavier bedrock material which forms the surrounding mountains and presumably the basin floor. The first step is to create a regional field. A regional field is an estimation of the values the CBA would have had if the light-weight sediments (the anomaly) had not been there. Since the valley-fill sediments are absent at the stations read in the mountains, one approach is to use the CBA values at bedrock stations as the basis for constructing a second order polynomial surface to represent a regional field over the valley.

Where there are insufficient bedrock stations to define a satisfactory regional trend, another approach is to estimate the regional by the process of upward continuation of the CBA field.

In Potential Theory, a field normal to a surface, regardless of its actual source, may be considered as originating in an areal distribution of mass on that surface. If the field strength is known, the surface density of mass (grams per square centimeter) can be calculated. The observed gravity field at the surface of the earth approximately fulfills the requirements of this theory. Thus, the observed (Bouguer anomaly) field can be used

to compute a surficial distribution of mass which would reproduce the field, and most importantly, account for the gravity field anywhere above the surface of observation. On this basis, the Bouguer anomaly field is readily "continued" to level surfaces above the ground.

An important property of such "upward continuation" is that the resultant field with increasing altitudes of continuation, changes more with respect to shallow sources than it does with respect to deeper sources. The anomalous parts of the field ascribed to shallow density distribution tend to vanish as the continuation is carried upward, whereas, the field produced by deeper sources changes only slightly. Therefore, upward continuations produce "regional" gravity fields.

The difference between the CBA and the regional field is called the "residual" field or residual anomaly. The residual field is the interpreter's estimation of the gravitational effect of the geologic anomaly. The zero value of the residual anomaly is not exactly at the rock outcrop line but at some distance on the "rock" side of the contact. The reason for this is found in the explanation of the terrain effect. There is a component of gravitational attraction from material which is not directly beneath a point.

If the "regional" is well chosen, the magnitude of the residual anomaly is a function of the thickness of the anomalous (fill) material and the density contrast. The density contrast is the difference in density between the alluvial and bedrock material.

If this contrast were known, an accurate calculation of the thickness could be made. In most cases, the densities are not well known and they also vary within the study area. In these cases, it is necessary to use typical densities for materials similar to those in the study area.

If the selected average density contrast is smaller than the actual density contrast, the computed depth to bedrock will be greater than the actual depth and vice-versa. The computed depth is inversely proportional to the density contrast. A ten percent error in density contrast produces a ten percent error in computed depth. An iterative computer program is used to calculate a subsurface model which will yield a gravitational field to match (approximately) the residual gravity anomaly.

The second vertical derivative (SVD) of the gravitational field is used to aid the interpreter in evaluating the subsurface mass distribution. Once the CBA field has been projected onto a uniform grid system, its SVD at the grid nodes is readily computed. In accordance with LaPlace's Equation in Free Space, the negative of the second vertical derivative is equal to the sums of the second derivatives in the x-direction and in the y-direction. The second vertical derivative is an indication of the curvature of the Bouguer anomaly field. In particular the zero-value of the SVD indicates the inflection in the field as it changes from "concave-upward" (algebraically negative SVD) to "convex-upward" (algebraically positive SVD). In a general way, the zero SVD falls on the tightest contours of the field. The

zero SVD contour line may be an indicator of a line of faulting, the pinchout of a stratum, truncation of a stratum at an unconformity or merely a marked change in shape or in density of a geologic unit.

APPENDIX A2.0

DUGWAY VALLEY, UTAH

GRAVITY DATA

DUGWAY VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG MIN	LONG. DEG MIN / ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM / OBSV GRAV / THEO GRAV	FAA	CBA +1000
U292	373020	113 98351759T	0	77437466	31395163439212480	-350	82077
U283	373025	113 10054990T	0	138437446	32661162683212487	1910	83308
1088	373083	113 92152740T	0	80437580	31487163150212573	180	82290
3161	373090	113 18056280T	0	133437569	32549161969212584	2310	83273
2479	373105	113 11154990T	0	230437594	32648162677212606	1790	83290
2480	373402	113 39459377T	0	155438153	32255160007213045	2810	82735
1089	373434	113 36759380T	0	151438211	32295160027213093	2780	82701
2481	373497	113 95852648T	0	94438348	31452164351213186	680	82844
U240	393754	113142847247T	0	69438840	30791167832213566	-1280	82679
1091	393774	113124448110T	0	73438870	31055166931213596	-1400	82263
1708	394010	113148846680T	0	67439315	30717168784213946	-1240	82907
1090	394018	113 38852641T	0	90439292	32290163968213957	-460	81680
1706	394101	113 2649931T	0	73439434	32811164867214080	-2230	80813
1707	394202	113100651919T	0	134439653	31415165504214230	110	82554
U202	394800	113 1225[illegible]	[illegible]	[illegible]440360	32695165464214820	-1850	81308
1092	394727	113125749160T	0	154440633	3108013[illegible]673[illegible]15[illegible]	-90	83304
1094	3948[illegible]8	1[illegible]3 [illegible]34[illegible]311[illegible]	[illegible]	[illegible]2440912	32677168190215262	-680	82582
WW0120	373052	1131260 5136S	0	79437535	310001[illegible]8810[illegible]12527	-383	82179
WW0121	373052	1131147 5105S	0	74437531	31161164042212527	-4[illegible]3	82[illegible]0
WW0122	373053	1131040 5174Y	0	73437529	31315163511212528	-330	82098
WW0123	373071	113 971 5226Y	0	77437560	31415163379212555	5	82258
WW0124	373077	113 944 5249Y	0	79437570	31453163275212564	109	82285
WW0125	373084	113 913 5274Y	0	80437582	31498163138212574	199	82290
WW0126	373090	113 884 5295Y	0	84437592	31540163175212583	419	82445
WW0127	373102	113 853 5325Y	0	85437613	31585163247212601	758	82681
WW0128	373109	113 826 5342Y	0	89437625	31624163228212611	889	82758
WW0129	373127	113 808 5362Y	0	91437658	31651163178212638	1003	82805
WW0130	373143	113 785 5392Y	0	95437687	31684162967212662	1046	82752
U275	373077	112537246647T	0	60437519	33706166954212564	-1720	82430
U274	373308	112552847057T	0	100437952	33492167138212906	-1490	82550
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U272	373589	112595052349T	0	113438484	32899164162213322	70	82353
U267	373603	112513347178T	0	48438485	34069167330213343	-1620	82328
U270	373700	112531150079T	0	81438685	33102165529213486	-840	82161
U269	373754	112573649318T	0	69438789	33812165972213566	-1190	82059
U271	373842	112593950220T	0	76438952	32925164689213677	-1780	81[illegible]6
U265	373866	112553048540T	0	65438984	33511166352213732	-1710	81795
U266	373934	112521748150T	0	53439100	33961166223213833	-2310	81323
U207	394121	112594349380T	0	71439468	32931165450214110	-2200	81031
U200	394193	112565650748T	0	90439593	33344165866214217	-600	82180

DUGWAY VALLEY GRAVITY DATA

STATION IDENT.	LAT DEG MIN	LONG DEC MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
U196	394249	1125271	50597T	0 82	439684	33896	165146	214300	-1550	81282
U198	394351	1125050	50919T	0 95	439867	34216	165464	214451	-1080	81645
U201	394427	1125685	54508T	0 119	440026	33312	164162	214563	860	82409
U203	394506	1125874	51870T	0 84	440178	33045	164868	214680	-1010	81384
U194	394617	1125268	56358T	0 146	440365	33915	163112	214845	1270	82216
U204	394699	1125761	54318T	0 114	440532	33214	164292	214967	410	82024
U205	394862	1125739	52549T	0 126	440833	33252	165971	215208	190	82406
U193	394869	1125281	56299T	0 158	440832	33906	164506	215219	2240	83218
U192	394902	1125240	56299T	0 170	440892	33966	164926	215267	2610	83600
U191	395012	1125208	53478T	0 131	441094	34016	166412	215431	1280	83191
U206	395024	1125979	48560T	0 84	441140	32916	168744	215448	-1010	82514
U189	395080	1125040	51837T	0 129	441215	34258	166959	215531	180	82649
U190	395214	1125264	49498T	0 86	441469	33944	168431	215730	-730	82466
1607	395256	1125401	48809T	0 88	441551	33750	169063	215792	-810	82628
1806	395111	113 510	54101T	0 139	441318	32163	166174	215577	1470	83179
[illegible]	395316	[illegible]	[illegible]T	0 75	441723	[illegible]	172567	215881	-1250	83575
DW0003	40 127	1131060	4367U	0 156	443217	31425	175697	217084	-293	84968
[illegible]	[illegible]	[illegible]	[illegible]U	[illegible]	[illegible]	[illegible]	[illegible]	217081	-1199	83680
DW0024	40 125	1125466	4494U	0 60	443161	33692	173606	217081	-1185	83547
SD0007	40 125	1125243	4506C	0 73	443154	34009	173366	217081	-1314	83391
DW0068	395691	113 250	4525U	0 118	442383	32558	173646	216438	-211	84474
DW0069	395722	113 378	5342S	27 865	442444	32377	168334	216484	2123	84795
DW0076	395745	113 730	6157S	117 807	442499	31877	163162	216517	4591	84515
DW0079	395995	113 942	5780S	2511458	442968	31586	165747	216888	3255	85250
DW0097	394706	113 250	5071S	0 87	440560	32517	165636	214977	-1619	81172
DW0202	393464	113 63	5872S	23 419	438257	32732	160194	213137	2321	82735
DW0310	394463	113 497	6029S	22 701	440119	32154	159082	214616	1207	81366
DW0311	394257	113 631	7046S	371522	439742	31953	152180	214311	4186	81713
DW0029	395687	1125240	4413S	0 149	442344	33996	172896	216431	-2008	83089
DW0032	395314	1125431	5296S	46 411	441659	33709	166598	215878	560	82954
DW0033	395438	1125444	4706B	0 86	441889	33696	170780	216062	-996	83039
DW0112	394924	1125874	5410Y	26 329	440952	33062	164470	215300	84	81987
DW0134	394436	1125279	5273Y	0 102	440031	33892	164584	214577	-369	81748
DW0151	394313	1125505	5484Y	0 142	439810	33564	163713	214394	929	82367
DW0222	393368	1125916	7298S	431701	438075	32938	150050	212995	5746	82599
DW0224	393179	1125871	7045V	541774	437724	32995	151885	212715	5478	83277
SD0014	395875	1125101	4565S	0 104	442687	34201	172115	216710	-1638	82896
SD0037	395292	1125138	54901T	1 313	441610	34126	164792	215845	613	82202
SD0143	394747	1125044	7305V	181345	440599	34239	151514	215038	5232	81680
DW0018	40 126	1125918	4457U	4 52	443177	33049	173837	217083	-1305	83549

DUGWAY VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG MIN	LONG. DEG MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM OBSV GRAV THEO GRAV	FAA	CBA +1000
DW0145	393974	1125585	5351Y	25	171439185	33437163711213892	176	82121
DW0183	393900	113 481	6114S	37	549439077	32152159173213782	2933	82665
DW0216	393699	1125960	5227Y	15	90438688	32889163846213484	-448	81829
DW0313	394173	113 262	5832S	36	367439575	32477159886214187	586	81098
DW0314	393842	113 173	5507S	37	129438960	32590161838213696	-32	81351
DW0315	394853	113 720	6810S	21	805440848	31852154623215195	3523	81122
DW0001	40 203	1131280	4845Y	37	222443365	31115172637217198	1033	84767
DW0113	394856	1125708	5595Y	33	178440821	33296164008215199	1465	82593
DW0120	394679	1125473	6345Y	126	364440486	33625158482214937	3262	82111
DW0130	395158	1125426	5288Y	4	206441371	33710166418215647	534	82708
DW0123	394867	1125538	5830Y	21	235440836	33539162426215215	2078	82450
DW0124	394982	1125611	5334Y	18	149441051	33440165739215386	550	82525
DW0312	394367	113 328	5601S	0	206439936	32391161970214474	207	81310
DW0002	40 213	1131172	4328U	0	85443380	31269175936217213	-549	84774
DW0004	40 61	113 918	4471U	0	140443090	31624175064216987	151	85042
DW0005	40 214	113 946	4327U	0	66443374	31591175204217214	-1292	84016
DW0006	40 128	113 833	4348U	0	84443211	31747175274217086	-897	84357
DW0007	40 213	113 721	4331U	0	57443364	31911175313217213	-1143	84142
DW0008	40 40	113 721	4403U	0	101443044	31903175090216955	-434	84650
DW0009	40 127	113 607	4353U	0	65443201	32069175198217084	-924	84294
DW0010	40 32	113 486	4405U	0	68443021	32237174844216944	-649	84395
DW0011	40 214	113 493	4342U	0	52443358	32235175590217214	-766	84477
DW0012	40 127	113 381	4374U	0	54443194	32390175177217084	-747	84388
DW0013	40 28	113 270	4423U	0	56443007	32544174090216938	-1227	83744
DW0014	40 215	113 259	4375U	0	48443352	32568175014217216	-1032	84094
DW0015	40 126	113 144	4419S	0	50443184	32727174005217083	-1495	83483
DW0016	40 34	113 41	4444U	0	52443011	32870173233216947	-1896	82999
DW0017	40 213	113 32	4424U	0	49443341	32890174054217213	-1529	83432
DW0019	40 39	1125805	4435U	0	53443012	33206173803216954	-1416	83510
DW0020	40 214	1125806	4459U	0	55443336	33212174239217214	-1015	83832
DW0022	40 37	1125580	4[illegible]5U	0	64443002	33526173372216951	-1091	83573
DW0023	40 212	1125580	4475U	0	55443325	33533173836217211	-1263	83529
DW0025	40 38	1125355	4504U	0	66442997	33846173166216952	-1404	83301
DW0026	40 214	1125355	4499U	0	65443322	33853173687217214	-1190	83530
SD0001	40 213	1125243	4511S	0	77443317	34012173898217213	-864	83827
SD0002	40 213	1125013	4524S	0	102443310	34339172860217213	-1781	82891
SD0006	40 124	1125129	4508S	0	88443149	34171172947217080	-1713	83000
SD0008	40 40	1125243	4505C	0	76442997	34006172967216955	-1596	83115
DW0053	395952	113 143	4463U	0	57442862	32722173035216825	-1793	83042
DW0054	395864	113 30	4479U	0	57442696	32879172483216695	-2063	82717

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DW0055	395778	113	143	4486U	0	68442540	32714172922216566	-1432	83336
DW0056	395691	113	30	4497U	0	64442376	32871171829216438	-2290	82436
DW0057	395604	113	145	4508S	0	86442218	32704172628216309	-1260	83451
DW0058	395535	113	56	4515U	0	74442088	32828171804216206	-1914	82760
DW0059	395517	113	144	4524U	0	91442057	32702172404216179	-1204	83457
DW0060	395430	113	138	4547U	0	89441896	32707171740216050	-1522	83059
DW0061	395317	113	29	4591U	0	73441684	32857170771215883	-1910	82505
DW0062	395307	113	171	4602U	0	94441670	32655171052215868	-1509	82889
DW0063	395350	113	317	4840B	0	163441754	32448170161215931	-225	83430
DW0066	395467	113	27747021T		0	193441969	32510171578216105	-279	83877
DW0067	395578	113	271	4580S	0	183442174	32524172971216270	-199	84362
DW0070	395814	113	38145522T		0	131442615	32377174404216620	621	85226
DW0071	395864	113	251	4485S	0	72442703	32564173744216695	-746	84029
DW0072	395937	113	377	4455S	0	79442842	32388174502216802	-378	84507
DW0073	395885	113	555	4872S	0	159442752	32132172455216725	1578	85120
DW0074	395763	113	513	5090S	0	144442525	32187171753216545	3108	85892
DW0077	395913	113	698	5245S	0	444442808	31930169467216767	2061	84615
DW0083	394707	113	703	5816S	0	203440577	31870161260214978	1018	81384
DW0084	394621	113	590	5543S	0	168440414	32028162912214851	227	81489
DW0085	394534	113	477	5390S	0	129440250	32185163833214722	-164	81581
DW0086	394585	113	374	5264S	0	100440341	32334164287214797	-972	81174
DW0087	394684	113	383	5137S	0	119440524	32326165339214944	-1263	81335
DW0088	394793	113	363	5102S	0	118440725	32359165875215105	-1217	81499
DW0090	394943	113	437	5722S	0	270441005	32260161417215328	-61	80693
DW0091	395131	113	495	5262S	0	137441355	32185167118215607	1030	83220
DW0092	395144	113	36548829T		0	145441375	32371169384215626	-288	83203
DW0093	395216	113	267	4694B	0	111441505	32514170480215733	-1081	83021
DW0094	395092	113	287	5091S	0	124441276	32480167601215549	-38	82722
DW0095	395021	113	263	4836S	0	126441144	32511169013215444	-922	82710
DW0096	394910	113	289	5290S	0	125440939	32470165452215279	-43	82039
DW0098	394619	113	253	5122S	0	84440400	32509165147214848	-1499	81115
DW0099	394534	113	253	5129S	0	85440242	32505165015214722	-1437	81154
DW0100	394620	113	141	5034S	0	78440398	32669165637214849	-1836	81072
DW0101	394534	113	28	5072S	0	78440235	32826165324214722	-1667	81112
DW0102	394707	113	28	5003S	0	81440555	32833166416214978	-1480	81537
DW0103	394793	113	140	4946S	0	81440718	32677167159215105	-1402	81810
DW0104	394926	113	29	5014B	0	87440960	32841167125215302	-993	81992
DW0105	394969	113	140	4835S	0	88441043	32685168947215366	-919	82678
DW0106	395056	113	29	4789S	0	80441201	32847169318215495	-1111	82635
DW0107	395142	113	140	4704S	0	83441364	32692169981215623	-1375	82664

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DW0108	375230	113 30	4642S	0	74441523	32852170692215753	-1379	82863
DW0171	394449	113 141	5093S	0	79440082	32661164783214595	-1884	80825
DW0172	394448	113 364	5266S	0	107440087	32343164054214594	-982	81164
DW0174	394360	113 476	5500S	0	144439928	32179162779214464	76	81461
DW0175	394361	113 252	5184S	0	91439922	32499164442214465	-1237	81173
DW0176	394274	113 139	5109S	0	80439758	32657164788214336	-1470	81185
DW0177	394360	113 28	5084S	0	74439913	32819164751214464	-1869	80865
DW0178	394188	113 27	4994S	0	74439595	32813165197214209	-2014	81027
DW0179	394101	113 139	5081S	0	83439438	32650164610214080	-1654	81099
DW0180	394188	113 364	5333S	0	114439606	32332163276214209	-745	81180
DW0181	394101	113 363	5285S	0	99439445	32330163537214080	-805	81268
DW0182	394013	113 476	5336S	0	98439286	32164164576213949	842	82740
DW0184	393927	113 364	5192S	0	104439123	32321164573213822	-390	82006
DW0185	394015	113 252	5155S	0	83439282	32485164494213952	-948	81554
DW0186	393929	113 139	5090S	0	88439120	32643164683213825	-1242	81485
DW0187	394015	113 26	5015S	0	71439275	32808164735213952	-2022	80944
DW0188	393842	113 25	5078S	0	85438955	32802164461213696	-1447	81318
DW0190	393841	113 364	5264S	0	105438964	32317164046213695	-109	82041
DW0192	393753	113 251	5306S	0	102438798	32475163244213565	-386	81618
DW0195	393579	113 26	5301S	0	124438468	32790163652213307	234	82277
DW0196	393579	113 252	5550S	0	120438476	32466162270213307	1193	82384
DW0201	393498	113 196	5596S	0	150438324	32543162081213187	1554	82617
DW0027	395949	1125242	4511S	0	78442829	34004173087216820	-1282	83409
DW0028	395863	1125241	4536S	0	80442669	34002173005216693	-1002	83607
DW0030	395762	1125348	4410U	0	102442486	33845173364216543	-1680	83381
DW0031	395526	1125277	5103S	0	174442047	33937168233216193	63	82832
DW0034	395600	1125465	4546S	0	86442190	33672172146216302	-1378	83203
DW0035	395799	1125529	4475U	0	65442560	33589173262216598	-1224	83577
DW0036	395888	1125540	4413U	0	63442725	33577173791216730	-1412	83600
DW0037	395951	1125468	4509U	0	63442839	33682172958216823	-1436	83249
DW0038	395951	1125692	4393U	0	57442846	33363173907216823	-1577	83497
DW0039	395778	1125692	4509U	0	57442526	33356172559216566	-1579	83100
DW0040	395690	1125580	4512U	0	64442360	33512172617216436	-1359	83316
DW0041	395596	1125692	4523U	0	64442189	33349172295216296	-1438	83200
DW0042	395516	1125577	4554S	0	69442038	33509171971216178	-1351	83185
DW0043	395428	1125691	4572U	0	66441878	33344171292216047	-1729	82742
DW0044	395316	1125633	4667U	0	74441669	33422170529215881	-1434	82723
DW0045	395316	1125803	4608U	0	69441675	33179170477215881	-2041	82311
DW0046	395430	1125918	4543U	0	64441889	33020171354216050	-1945	82624
DW0047	395516	1125806	4530U	0	63442045	33183171902216178	-1646	82966

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DW0048	395604	1125918	4509U	0	60442211	33027171931216309	-1945	82736
DW0049	395690	1125806	4511U	0	58442367	33190172389216436	-1596	83075
DW0050	395778	1125919	4501U	0	56442533	33033172332216566	-1879	82825
DW0051	395866	1125805	4492S	0	55442692	33199172798216697	-1627	83107
DW0052	395951	1125916	4483U	0	53442853	33045172955216823	-1683	83080
DW0109	395235	1125882	4645B	0	72441527	33063170027215761	-2023	82206
DW0110	395141	1125917	4722B	0	75441355	33010169333215622	-1849	82119
DW0111	395007	1125759	4977B	0	98441102	33230167877215423	-706	82415
DW0114	394821	1125972	5149Y	0	92440764	32918166263215147	-429	82102
DW0115	394730	1125872	5262Y	0	101440593	33057165101215012	-390	81763
DW0116	394652	1125745	5548Y	0	144440444	33235163576214896	891	82112
DW0117	394598	1125924	5167Y	0	82440350	32977165192214816	-999	81459
DW0125	394972	1125330	5374Y	0	123441024	33840165989215371	1192	82986
DW0126	395073	1125533	4986Y	0	109441217	33555168232215520	-369	82735
DW0127	395123	1125712	4808Y	0	82441315	33301168884215595	-1465	82218
DW0128	395228	1125724	4692B	0	73441509	33288169768215751	-1833	82239
DW0129	395186	1125578	4803Y	0	81441427	33495169488215688	-1000	82698
DW0131	395086	1125277	5208Y	0	106441233	33920166722215540	194	82537
DW0132	395208	1125261	4977B	0	84441458	33948168363215721	-519	82589
DW0133	393795	1125175	4782Y	0	51438842	34016166568213627	-2056	81685
DW0135	394360	112535452470T		0	100439892	33782164582214464	-503	81701
DW0136	394262	1125397	5126B	0	91439712	33717165285214319	-795	81813
DW0137	394229	112530450561T		0	78439648	33848165259214270	-1430	81403
DW0138	394133	1125344	4981B	0	69439472	33787165722214127	-1531	81549
DW0139	394016	1125295	4870B	0	59439254	33853166138213954	-1987	81462
DW0140	393954	1125427	5001Y	0	69439143	33662165390213863	-1409	81603
DW0141	393907	1125285	4825B	0	53439052	33863166208213793	-2178	81418
DW0142	393789	1125325	4786Y	0	55438835	33801166456213618	-2122	81609
DW0143	393837	112546648379T		0	57438928	33601166170213689	-1991	81565
DW0144	393886	1125561	5055Y	0	82439022	3346716516021376[illegible]	-1031	81810
DW0146	394054	1125457	4980B	0	67439329	3362316596021401[illegible]	-1188	81895
DW0147	394055	1125578	5277Y	0	105439335	33450163968214012	-383	81724
DW0148	394185	112548551352T		0	89439573	33588165591214205	-289	82286
DW0149	394190	112555751991T		0	82439584	33485165659214212	375	82725
DW0150	394295	1125626	5385Y	0	134439780	33391164537214367	849	82616
DW0152	394464	112542855951T		0	126440087	33680162953214618	990	82033
DW0153	394382	1125709	5466Y	0	115439944	33276163872214496	816	82288
DW0154	394273	1125749	5138B	0	87439743	33214165268214335	-714	81849
DW0155	394186	112569151050T		0	80439581	33294165881214206	-283	82385
DW0156	394165	112577950259T		0	71439545	33167165654214175	-1223	81706

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DW0157	394056	1125766	4970Y	0	67439343	33181165943214013			-1299	81816
DW0158	394055	1125682	5051Y	0	73439338	33301166108214012			-370	82475
DW0159	393936	1125791	4924B	0	65439121	33140165818213836			-1678	81592
DW0160	393960	1125668	4980Y	0	66439162	33317166029213871			-977	82104
DW0161	393822	1125699	4885Y	0	65438908	33267166249213666			-1447	81957
DW0162	393794	112584849639T		0	74438860	33053165414213625			-1496	81647
DW0163	393752	1125742	4932U	0	69438779	33203165982213563			-1166	82081
DW0164	393924	1125915	4982B	0	67439103	32963165116213818			-1819	81256
DW0165	394054	1125916	4968C	0	65439344	32967165162214010			-2096	81024
DW0166	394138	112588349731T		0	67439498	33017165450214135			-1886	81220
DW0167	394245	1125948	5007B	0	73439698	32929165251214293			-1924	81072
DW0168	394297	1125861	5083Y	0	78439791	33055165244214370			-1292	81449
DW0169	394397	1125882	5146B	0	90439977	33029165085214519			-1006	81532
DW0170	394494	1125847	5258Y	0	85440155	33083164753214663			-427	81724
DW0217	393663	112580250239T		0	83438617	33114165622213431			-530	82417
DW0218	393582	1125959	5246Y	0	116438472	32886164189213312			247	82471
DW0219	393576	1125709	4927Y	0	91438453	33243165862213302			-1074	82212
DW0220	393473	1125837	5386Y	0	227438266	33056163470213150			1008	82865
DW0221	393378	1125770	5410Y	0	276438089	33148163272213009			1176	83000
DW0223	393261	1125766	5330B	0	349437872	33149163925212836			1249	83419
DW0225	393077	1125721	5345Y	0	266437530	33206163472212564			1209	83245
DW0226	393094	1125565	4805B	0	101437557	33430166221212589			-1149	82563
DW0227	393200	1125647	4880B	0	168437755	33317166220212746			-603	82921
DW0228	393268	1125503	4682Y	0	90437877	33526167304212847			-1483	82639
DW0229	393323	1125636	4830B	0	149437983	33338166470212928			-1005	82670
DW0230	393443	1125620	4790Y	0	113438204	33365166600213105			-1429	82347
DW0231	393549	1125540	4795B	0	71438398	33484166573213263			-1567	82150
DW0232	393623	112544547779T		0	60438532	33623166429213372			-1979	81784
DW0233	393671	112555248159T		0	65438624	33472166285213443			-1837	81802
DW0234	393713	112565048750T		0	67438704	33333166067213505			-1562	81878
DW0235	393738	1125495	4812U	0	57438746	33556166277213542			-1982	81663
DW0236	393692	1125347	4767U	0	57438656	33766166494213474			-2120	81678
DW0237	393545	112525347090T		0	51438382	33895167243213256			-1700	82290
DW0238	393515	1125385	4741Y	0	59438330	33705167091213213			-1506	82382
DW0239	393421	1125281	4662B	0	52438153	33850167698213073			-1503	82648
DW0240	393411	1125467	4715B	0	67438140	33583167378213058			-1311	82675
DW0241	393316	1125355	4636U	0	60437961	33740168259212918			-1032	83216
DW0242	393210	1125293	4615B	0	55437763	33824168160212761			-1170	83144
DW0243	393173	1125444	4677Y	0	69437699	33607167226212706			-1467	82650
DW0244	393088	1125386	4685B	0	64437540	33686167013212580			-1479	82605

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DW0245	393081	1125282	4627U	0 52437524	33835167809212570	-1218	83052
DW0246	393014	1125445	4758B	0 74437405	33599166321212470	-1375	82471
DW0247	393002	1125331	4672Y	0 58437380	33762166957212453	-1530	82593
DW0248	393660	1125192	4746U	0 52438593	33986167024213427	-1741	82124
DW0309	395868	1125395	4508B	0 68442683	33783172725216700	-1552	83139
SD0012	395933	1125003	4620S	0 143442792	34343171464216797	-1857	82528
SD0013	395970	1125117	4533S	0 98442864	34182172275216852	-1919	82718
SD0021	395775	1125129	4559S	0 106442503	34158172513216562	-1147	83409
SD0022	395688	1125016	4818S	0 116442339	34315170225216433	-870	82814
SD0025	395576	1125160	4498S	0 123442136	34106171904216266	-2036	82746
SD0026	395513	1125017	4489S	0 163442015	34307171461216173	-2472	82381
SD0150	394452	1125135	5367Y	0 118440056	34098164265214600	173	81986
SD0151	394361	1125227	5201Y	0 90439890	33963164770214465	-749	81602
SD0152	394306	1125144	5103Y	0 84439786	34080165090214384	-1270	81409
SD0153	394343	1125029	5144Y	0 99439851	34246165441214438	-589	81965
SD0161	394187	1125033	4924Y	0 66439563	34234165966214207	-1903	81368
SD0162	394137	1125188	4940B	0 63439475	34010165688214134	-1957	81257
SD0163	394098	1125014	4859V	0 59439398	34258166317214076	-2032	81454
SD0169	394022	1125139	4847B	0 56439261	34076166286213963	-2064	81461
SD0170	393899	1125127	4801B	0 52439033	34089166459213780	-2142	81535
SD0176	393796	1125018	4829U	0 49438839	34241166753213628	-1431	82148
SD0219	393571	1125118	4707U	0 48438426	34089167324213295	-1676	82318
SD0221	393489	1125131	4670V	0 48438274	34067167591213173	-1636	82484
SD0223	393402	1125018	4643U	0 54438110	34226167914213045	-1439	82779
WW0001	393315	1125131	4620U	0 51437953	34061168083212916	-1357	82937
WW0003	393242	1125032	4603U	0 50437815	34200168303212808	-1189	83161
WW0005	393182	1125137	4596U	0 47437707	34047168270212720	-1198	83173
WW0007	393140	1125018	4592U	0 44437626	34216168325212657	-1121	83262
WW0009	393053	1125131	4592V	0 45437468	34051168165212528	-1150	83233
FSF064	395945	1131389	5607C	565 900442891	30948166112216815	2065	84406
FSF065	395875	113142143330T		4 109442763	30899175072216711	-865	84470
FSF076	395887	1131116	6266C	5841047442775	31334162113216729	4357	84616
FSF094	395108	113 688	5418C	145 149441319	31909165320215573	736	82551
FSF102	394626	1131121	5163I	8 194440442	31270166382214858	112	82704
FSF113	394856	1131374	5202C	195 202440876	30919167508215199	1264	83919
FSF229	393576	1131375	4885I	5 91438508	30859166892213303	-435	82998
FSF[illegible]	394098	1131375	4729S	4 73439474	30883168004214076	-1569	82378
FSF234	394437	1131362	4757I	11 113440101	30917168962214578	-855	83046
FSF253	394286	1131000	5323I	21 174439809	31427164847214354	592	82630
FSF255	394025	1131061	5410S	413 179439328	31328163919213968	865	83005

DUGWAY VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG MIN	LONG. DEG MIN	ELEV. +CODE	TER-COR. IN/OUT NORTH UTM	EAST UTM OBSV GRAV THEO GRAV	FAA	CBA +1000
FSF264	393567	113 949	5827S	340 321438477	31468160597213290	2147	82934
FSF269	394442	113 799	7112S	7031287440090	31721152111214586	4465	82198
FSF272	393647	113 754	6736S	591 910438618	31751154434213408	4424	82951
FSF309	393187	113 633	6002S	201 208437763	31904158792212727	2552	82490
FSF310	40 77	1131189	5573C	457 572443129	31239167475217011	2912	84933
FSF311	394844	113 801	6870C	21 948440834	31736154118215182	3597	81134
FSF270	394130	113 820	5636S	9 219439514	31678162099214123	1017	82022
FSF266	393849	113 872	5552S	31 169438996	31591162987213707	1531	82794
FSF263	393406	113 951	5609S	44 173438179	31458161943213051	1679	82766
FSF252	394489	1131099	6584V	651238440188	31295156591214655	3903	82750
FSF120	395089	1131451	5712C	42 730441310	30820164428215545	2640	83930
FSF101	394740	1131107	5686C	25 336440652	31295163559215027	2044	83011
FSF096	395100	113 823	5531C	40 205441308	31716164315215561	807	82187
FSF092	395368	113 692	5233C	31 138441800	31915167623215959	911	83232
FSF086	395707	113 838	6748V	391484442432	31722158816216462	5865	84372
FSF085	395866	113 886	5608C	9 299442728	31660167526216698	3606	84787
FSF084	395702	1131006	5676C	11 503442428	31482166237216454	3200	84355
FSF075	395775	1131210	5165C	154 290442571	31195169339216563	1383	84210
FSF002	40 204	1131279	4845C	47 222443367	31117172629217199	1024	84768
FSF251	394277	1131142	5260S	12 138439797	31224165434214341	594	82803
FSF228	393480	1131394	5578S	31 357438331	30827162014213161	1349	82712
DW0091	395131	113 495	5262C	0 137441355	32185167115215607	1028	83218
DW0092	395144	113 365	48829T	0 145441375	32371169382215626	-292	83198
FSF061	395594	1131466	43081T	0 62442245	30822174245216294	-1510	83858
FSF062	395779	1131488	4296S	0 68442588	30799174933216568	-1210	84206
FSF063	395954	1131488	4301S	0 89442912	30808175172216828	-1182	84237
FSF066	395797	1131346	4353S	0 140442616	31002174898216595	-734	84559
FSF067	395691	1131368	4325I	0 83442421	30966174902216438	-836	84495
FSF068	395514	1131383	4337I	0 67442094	30937173971216175	-1389	83884
FSF069	395296	1131379	4436S	0 75441690	30932172751215852	-1356	83589
FSF070	395316	1131254	4471S	0 76441723	31111172566215881	-1242	83584
FSF071	395401	1131307	4420S	0 69441882	31040172798216008	-1616	83378
FSF072	395511	1131234	4420S	0 79442083	31149173501216171	-1076	83927
FSF073	395617	1131243	4434S	0 93442279	31141173925216328	-678	84292
FSF074	395732	1131214	4622C	0 150442491	31187173132216499	129	84514
FSF077	395672	1131099	4729I	0 184442376	31348172134216410	227	84281
FSF078	395547	1131101	4589S	0 99442145	31340172483216224	-557	83890
FSF079	395430	1131162	4491S	0 78441931	31248172834216051	-955	83806
FSF080	395362	1131132	4547S	0 77441804	31287172497215950	-664	83905
FSF081	395312	1131040	4635I	0 84441708	31416171533215876	-725	83550

DUGWAY VALLEY GRAVITY DATA

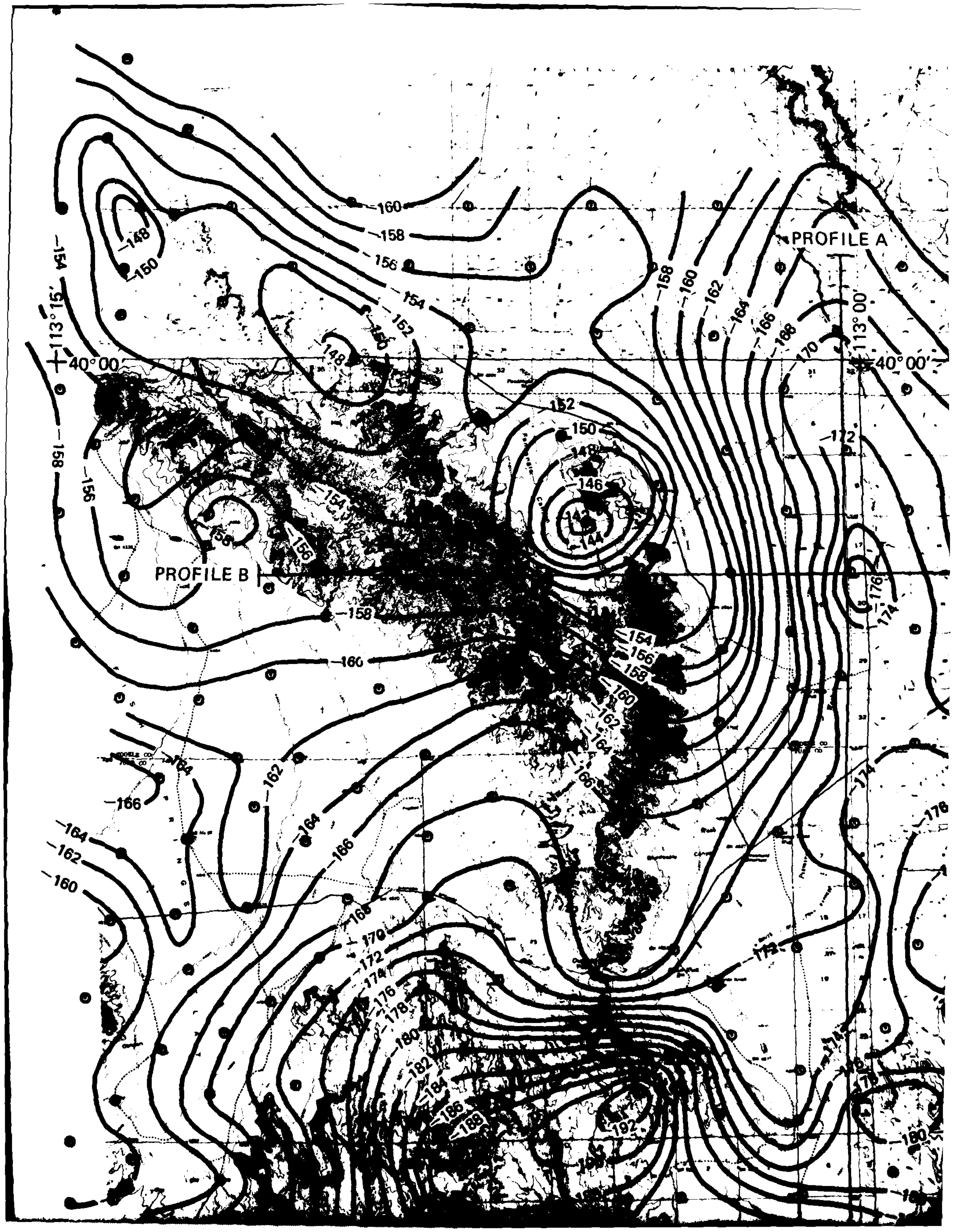
STATION IDENT.	LAT. DEG MIN	LONG. DEG MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM OBSV GRAV THEO GRAV	FAA	CBA +1000
FSF082	395430	1131049	4600S	0	87441927	31409172070216051	-693	83705
FSF083	395632	113 994	4959I	0	165442299	31496170605216350	922	84173
FSF087	395526	113 897	4926C	0	136442099	31630170381216193	545	83880
FSF088	395388	113 943	4785S	0	95441845	31558170738215988	-221	83554
FSF089	395315	113 813	4914C	0	103441706	31740169392215880	-244	83098
FSF090	395430	113 814	4983S	0	122441919	31744169506216051	349	83476
FSF091	395475	113 653	5987C	0	458441996	31975163106216117	3335	83373
FSF093	395241	113 664	5032I	0	130441564	31949168387215770	-31	82937
FSF097	395229	113 815	4906C	0	119441547	31733169227215752	-357	83029
FSF098	395230	113 965	4773I	0	101441554	31519170338215754	-500	83322
FSF099	395146	1131020	4788I	0	129441400	31437169742215629	-826	82971
FSF100	394962	1131068	5034I	0	239441062	31361167615215356	-367	82702
FSF103	394557	1131353	4806I	0	130440322	30935168935214756	-590	83146
FSF104	394729	1131258	4916C	0	159440637	31079168677215011	-71	83321
FSF105	394826	1131211	4990C	0	182440815	31150168595215155	400	83562
FSF106	394950	1131227	4830I	0	122441045	31133169484215339	-401	83247
FSF107	395038	1131197	4731I	0	110441207	31180170308215469	-638	83335
FSF108	395083	1131110	4757C	0	124441287	31306169967215536	-603	83096
FSF109	395218	113114945751T		0	86441538	31257171996215736	-688	83794
FSF110	395209	1131282	4514I	0	83441526	31067172092215723	-1152	83535
FSF111	395129	1131260	45939	0	92441377	31094171641215604	-743	83685
FSF112	395015	1131314	4721C	0	100441168	31012170589215435	-4[illegible]7	83579
FSF114	394774	1131345	4727I	0	117440724	30957170215215078	-382	83614
FSF115	394676	1131419	4904C	0	141440545	30847168777214932	-5	83410
FSF116	394611	1131495	4573I	0	92440427	30735170719214836	-1085	83411
FSF117	394792	1131489	4580S	0	94440762	30752171380215104	-624	83849
FSF118	394881	1131486	4687I	0	93440927	30760170922215236	-204	83901
FSF119	394942	1131400	4816C	0	93441036	30886170040215327	34	83701
FSF121	395200	113140244970T		0	116441514	30895172692215709	-699	84079
FSF217	394487	1131483	4546I	0	94440198	30746170404214652	-1470	83119
FSF218	394362	1131485	4551S	0	87439966	30738169822214467	-1818	82747
FSF219	394185	1131486	4609S	0	74439639	30728169078214205	-1754	82600
FSF220	394009	1131485	4668S	0	67439313	30721168769213944	-1247	82899
FSF221	393837	1131487	4660S	0	69438995	30711168239213689	-1597	82578
FSF222	393663	1131486	4778I	0	69438673	30704167602213432	-870	82904
FSF223	393314	1131484	5070S	0	86438028	30691165258212915	56	82849
FSF225	393052	1131373	5233S	0	89437539	30838162983212527	-297	81944
FSF226	393226	1131373	5134S	0	77437861	30846164423212785	-47	82520
FSF227	393386	1131354	5172C	0	94438156	30880164756213022	408	82861
FSF230	393752	1131377	4748C	0	70438834	30864167620213563	-1262	82614

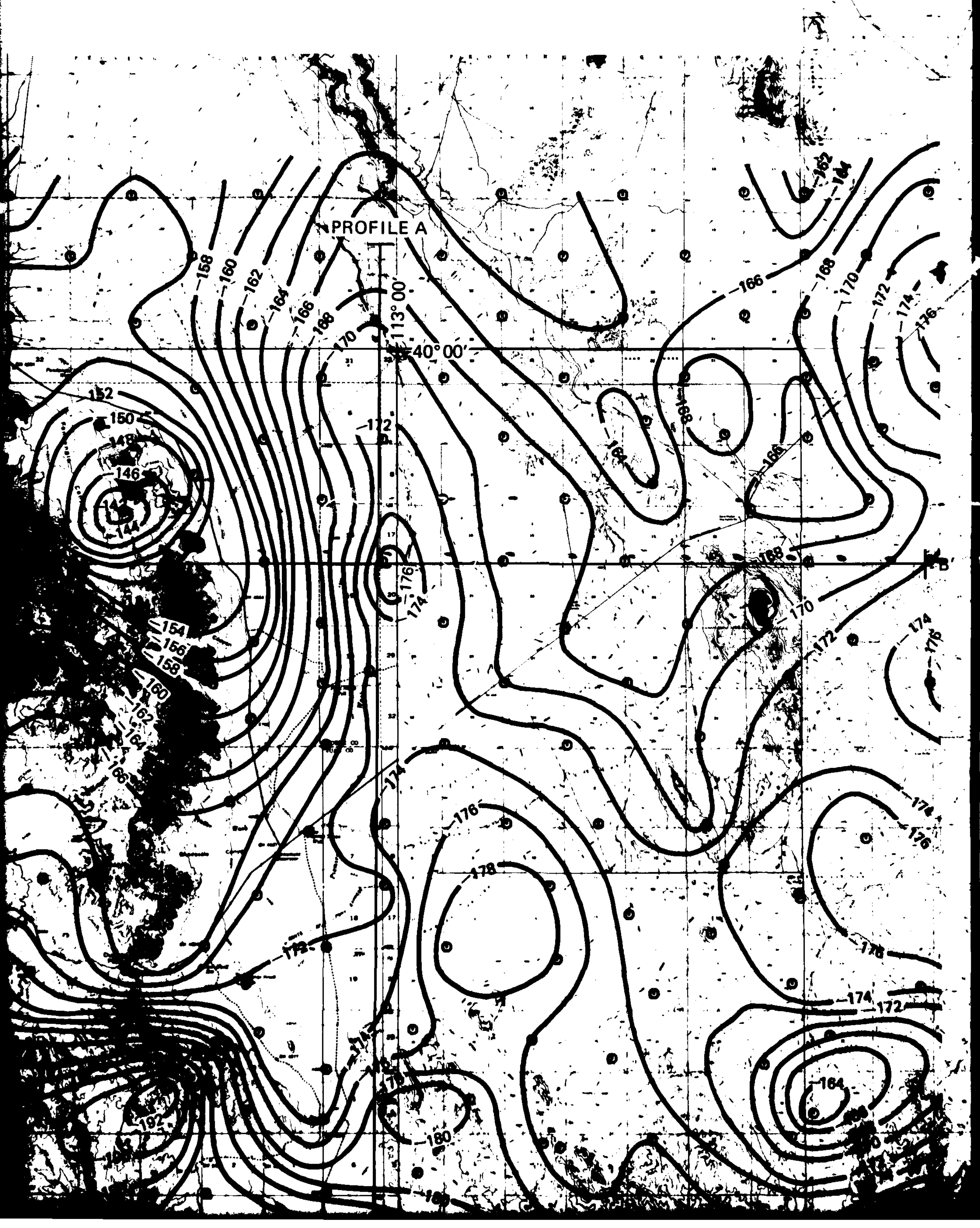
DUGWAY VALLEY GRAVITY DATA

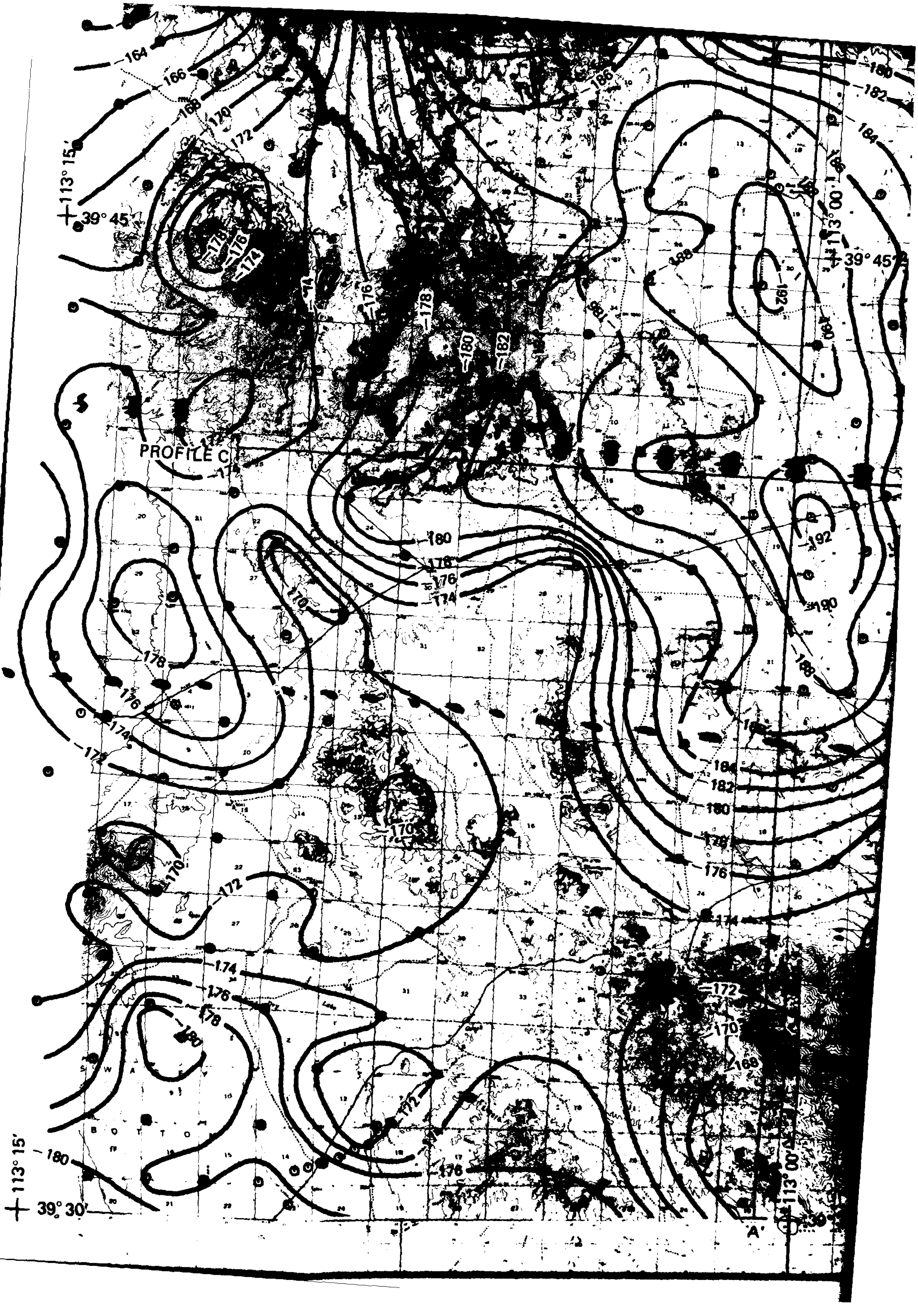
STATION IDENT.	LAT. DEG MIN	LONG. DEG MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM / OBSV GRAV / THEO GRAV	FAA	CBA +1000
FSF231	393923	1131375	4749C	0	65439150	30875167434213817	-1692	82176
FSF233	394271	1131373	4725S	0	94439794	30894168505214332	-1362	82616
FSF235	394496	1131221	5326S	0	186440205	31121164578214666	35	82056
FSF236	394362	1131213	5318C	0	186439957	31126165196214467	776	82824
FSF237	394184	1131263	4858S	0	91439629	31047167746214203	-740	82781
FSF238	394009	1131264	4794I	0	76439305	31037167395213944	-1436	82290
FSF239	393936	1131262	4798C	0	71439170	31037167088213836	-1596	82111
FSF240	393662	1131261	4876S	0	78438663	31026166893213430	-650	82797
FSF241	393489	1131262	5115I	0	75438343	31017165392213174	356	82984
FSF242	393315	1131262	5025I	0	73438022	31009164645212916	-980	81953
FSF243	393139	1131261	5102S	0	76437696	31002164052212656	-590	82084
FSF244	393052	1131147	5105S	0	74437531	31162163863212527	-622	82041
FSF245	393266	1131199	5076I	0	71437929	31097164247212844	-824	81933
FSF246	393403	1131150	510[illegible]	[illegible]	73438180	3117[illegible]5097[illegible]8047	46	82724
FSF247	393576	1131149	5044S	0	77438500	31182165886213303	51	82924
FSF248	393752	1131148	4895S	0	81438826	31192166412213563	-1086	82299
FSF249	393926	1131152	4878S	0	77439148	31194167126213821	-790	82650
FSF250	394097	1131152	4941S	0	89439464	31202166794214074	-782	82454
FSF254	394203	1131004	5192C	0	146439655	31418165491214231	122	82559
FSF256	393887	1131036	4942C	0	83439072	31358166727213763	-529	82698
FSF257	393663	1131036	5143S	0	96438657	31348165306213432	274	82828
FSF258	393492	1131036	5171I	0	82438341	31340164779213179	266	82711
FSF259	393314	1131038	5217C	0	75438012	31329163973212915	155	82436
FSF260	393139	1131037	51989	0	73437688	31323163667212656	-72	82272
FSF261	393083	113 916	5274S	0	80437580	31494163143212573	203	82295
FSF262	393226	113 929	5311I	0	82437845	31482163631212785	831	82797
FSF265	393761	113 947	51979	0	142438836	31480165157213577	484	82902
FSF267	393924	113 926	51373	0	91439136	31517165961213818	486	83057
FSF268	394098	113 925	5157S	0	116439458	31526165002214076	-542	81984
FSF271	394015	113 811	5155S	0	102439301	31685165024213953	-416	82104
FSF273	393447	113 748	55190T	0	101438248	31751162704213112	1532	82809
FSF274	393314	113 812	5431S	0	89438004	31653162816212915	1012	82578
FSF275	393138	113 812	5381S	0	90437679	31645162992212655	978	82715
FSF276	393225	113 699	5541S	0	106437836	31811162189212783	1553	82760
FSF003	40 324	1131256	43159T	0	54443588	31155175787217378	-976	84357
FSF004	40 427	1131368	4316Y	0	56443782	31000175662217530	-1254	84082
FSF005	40 313	1131403	4313S	0	53443573	30945176185217361	-590	84753
FSF006	40 214	1131341	4324Y	0	69443387	31029176364217214	-160	85161
FSF007	40 126	1131371	4330S	0	84443226	30982176054217084	-283	85032
FSF008	40 60	1131376	4355S	0	108443104	30972175662216986	-342	84912

DUGWAY VALLEY GRAVITY DATA

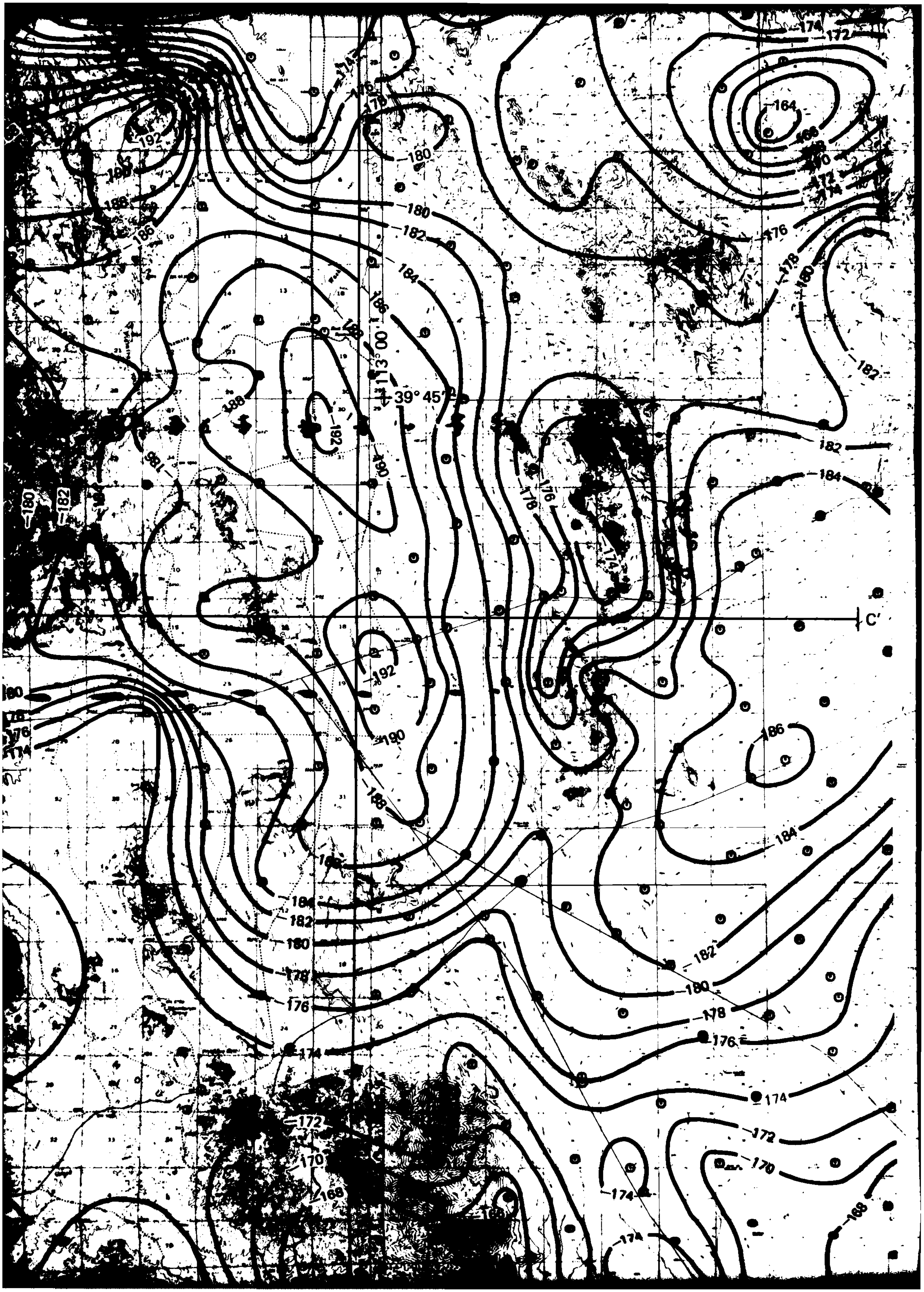
STATION IDENT.	LAT. DEG	MIN	LONG. DEG	MIN	ELEV.	+CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
FSF009	40	41	113	1487	4301	Y	0	70443073	30813	175519	216957	-965	84436
FSF010	40	214	113	1488	4302	Y	0	53443393	30820	175908	217214	-823	84557

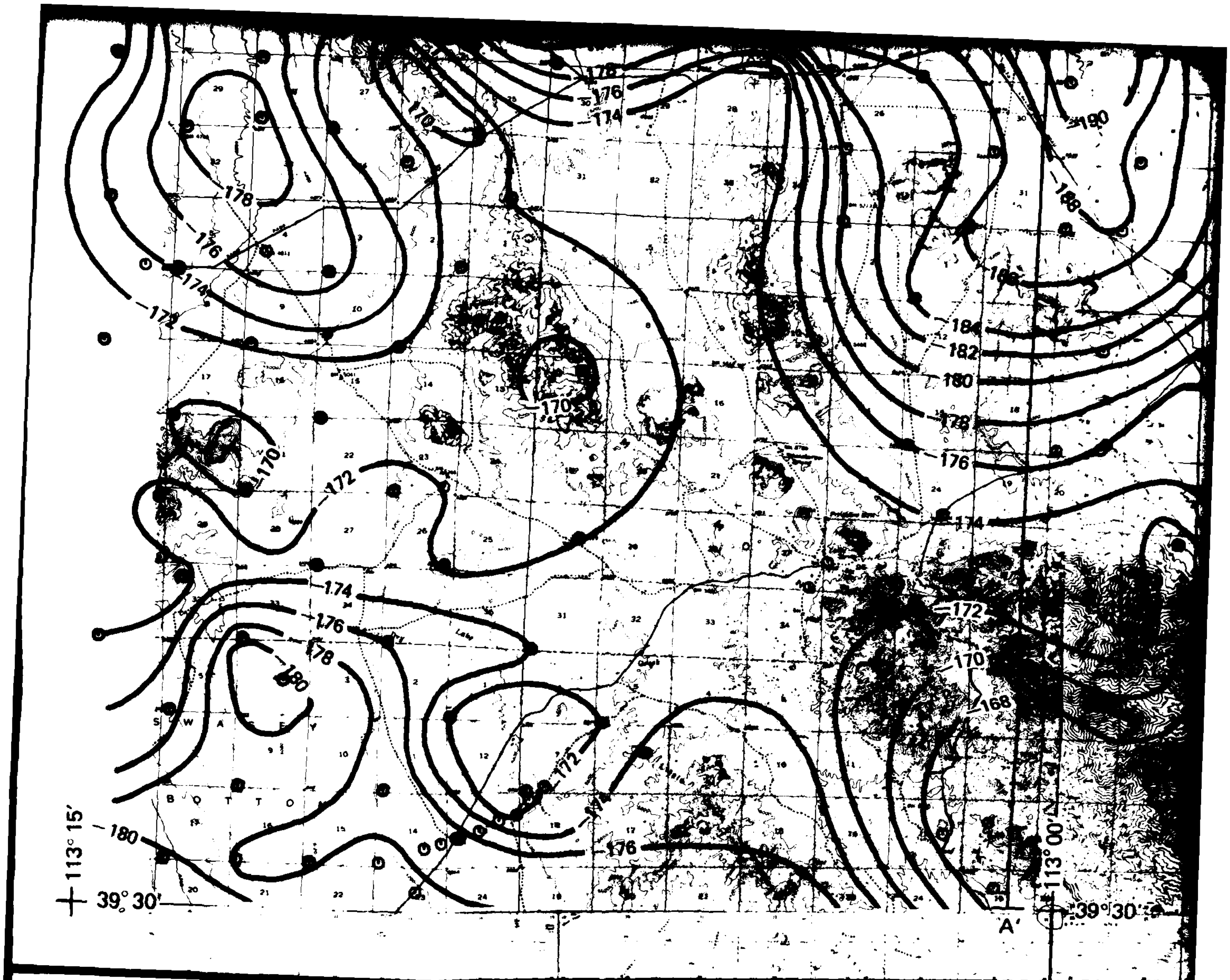

PROFILE A
PROFILE B
113°15'
113°00'
40°00'
40°00'
148
150
152
154
156
158
160
162
164
166
168
170
172
174
176
178
180
182
184
186
188
192


PROFILE A
113° 00'
40° 00'
B'



113° 15'
39° 45'
113° 00'
39° 45'
113° 15'
39° 30'
113° 00'
PROFILE C
A'
164
166
168
170
172
174
176
178
180
182
184
186
188
190
192


113°00'
39° 45'
C'
164
166
168
170
172
174
176
178
180
182
184
186
188
190
192



EXPLANATION

● GRAVITY FIELD STATIONS

—175— CBA GRAVITY CONTOURS

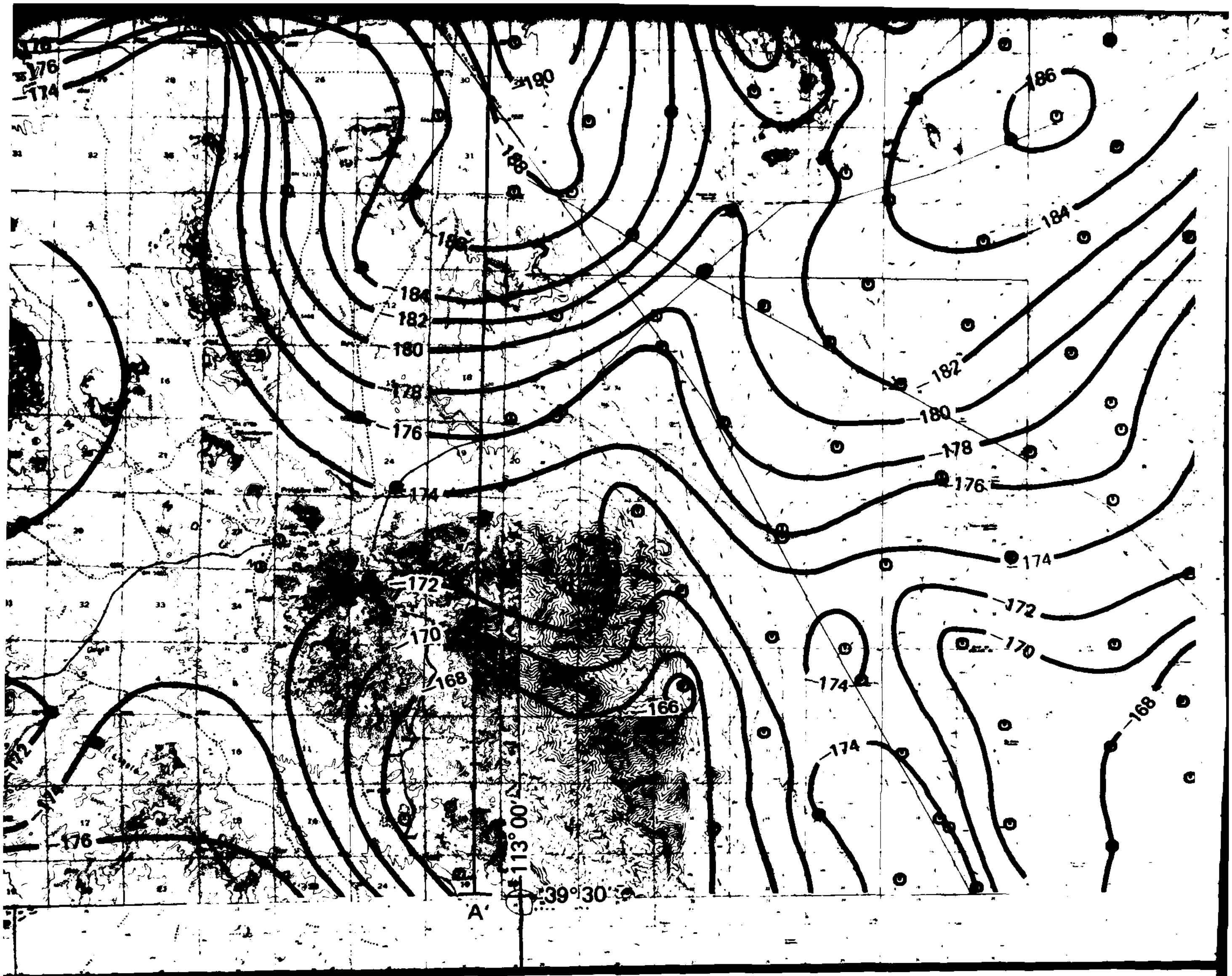
CONTOUR INTERVAL = 2 MILLIGALS

NORTH

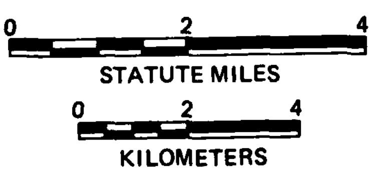
SCALE 1: 125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS



SCALE 1: 125,000



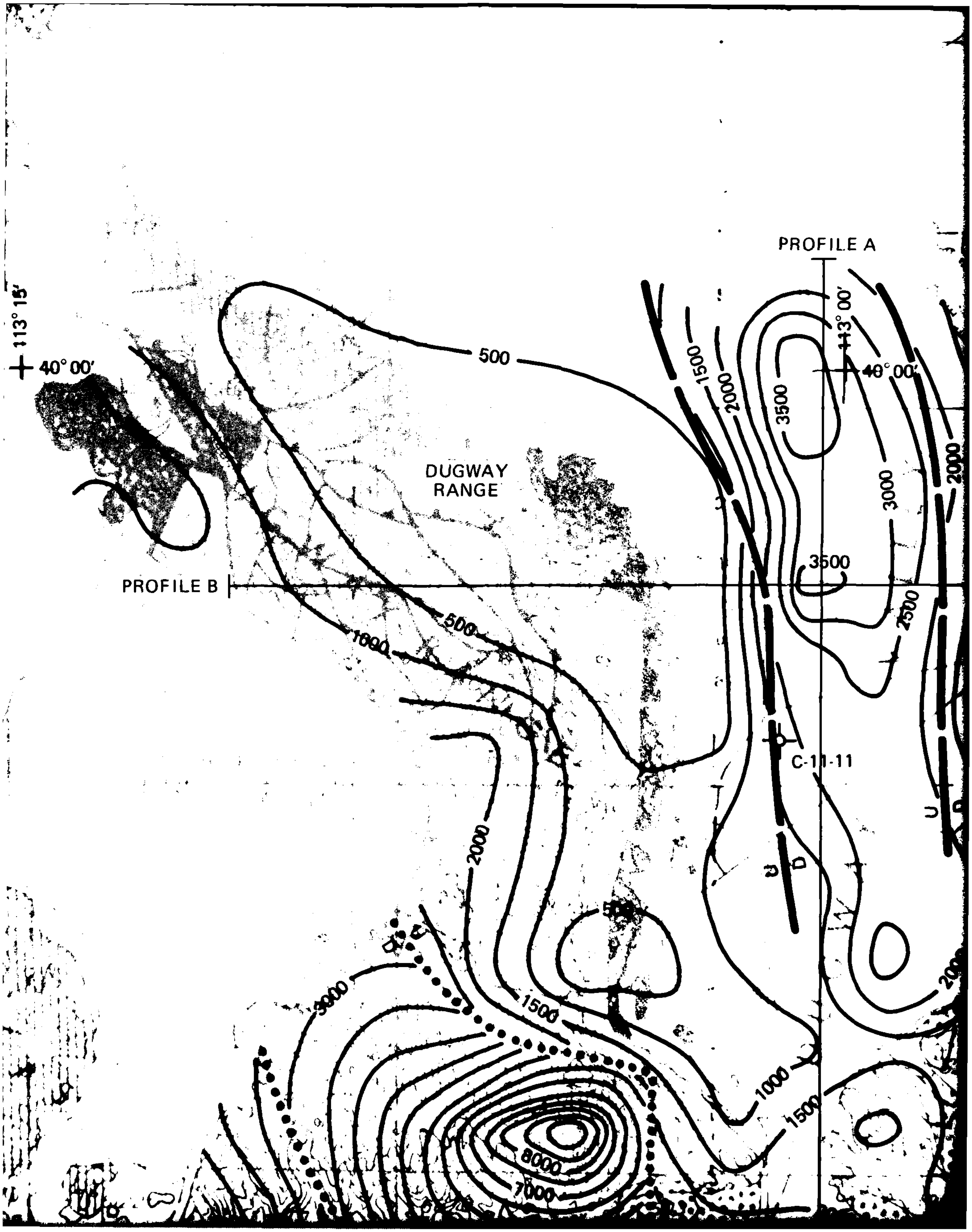
Ertec
The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

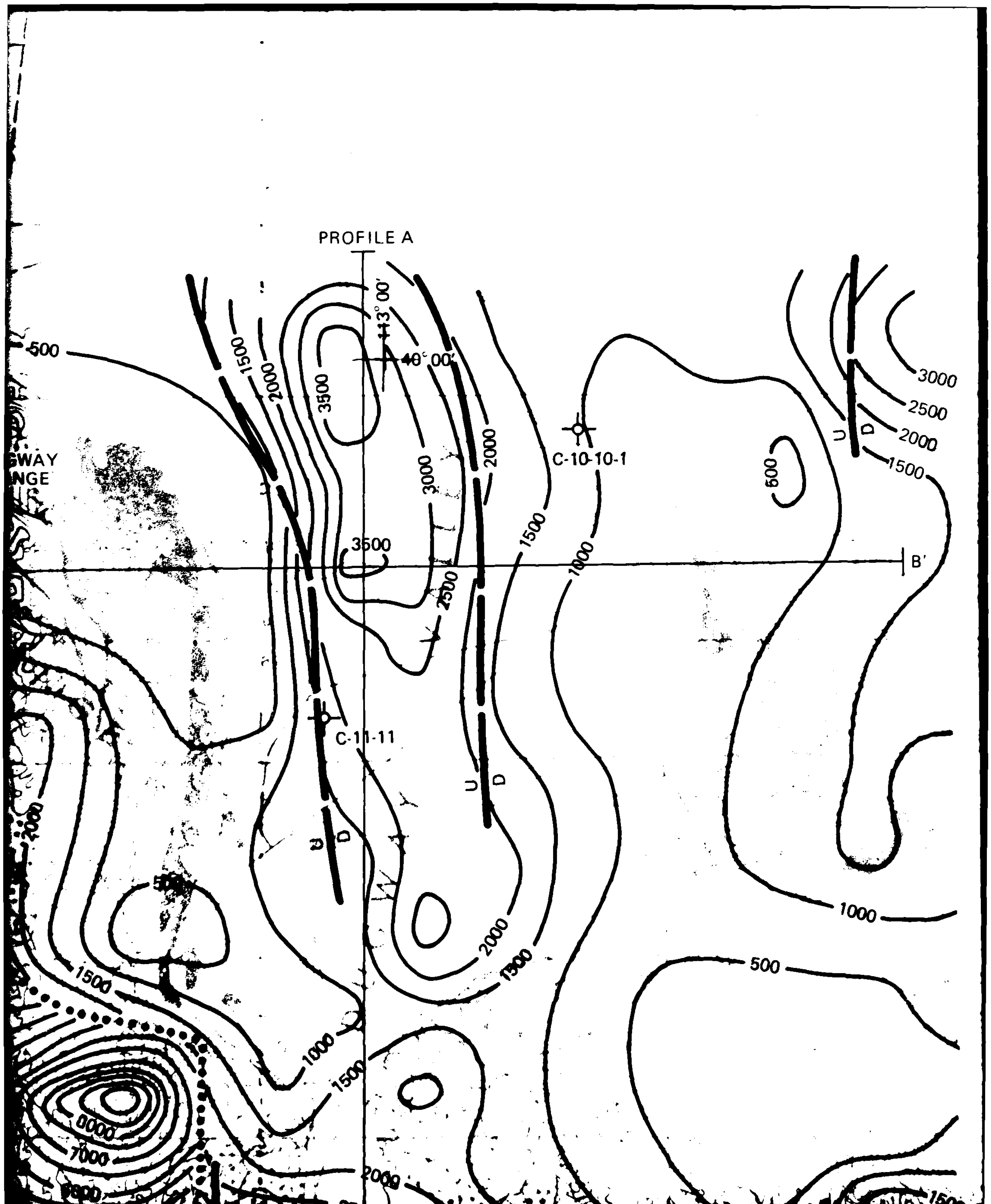
COMPLETE BOUGUER
ANOMALY CONTOURS
DUGWAY VALLEY, UTAH

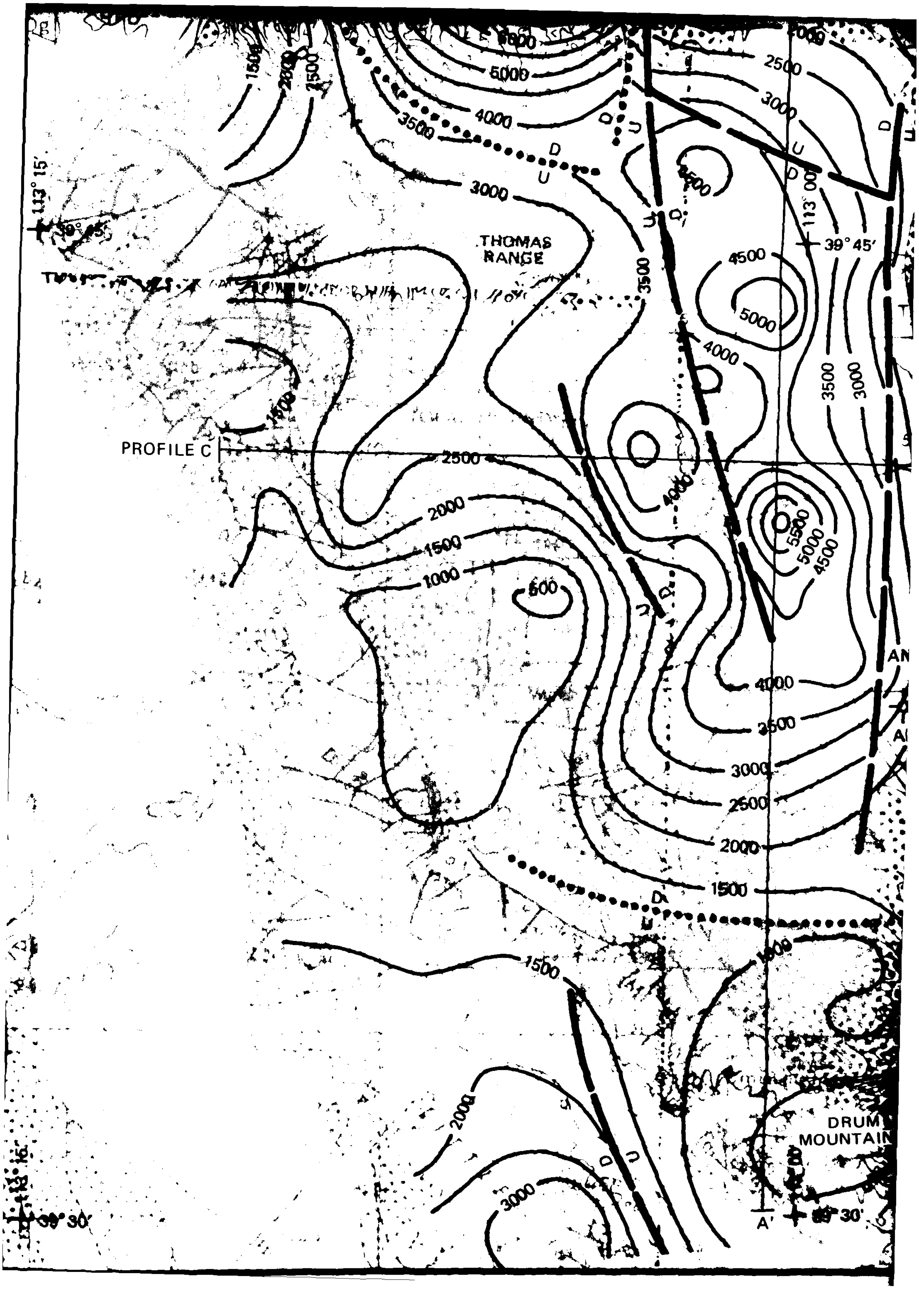
19 DEC 80
28 AUG 81 Revised

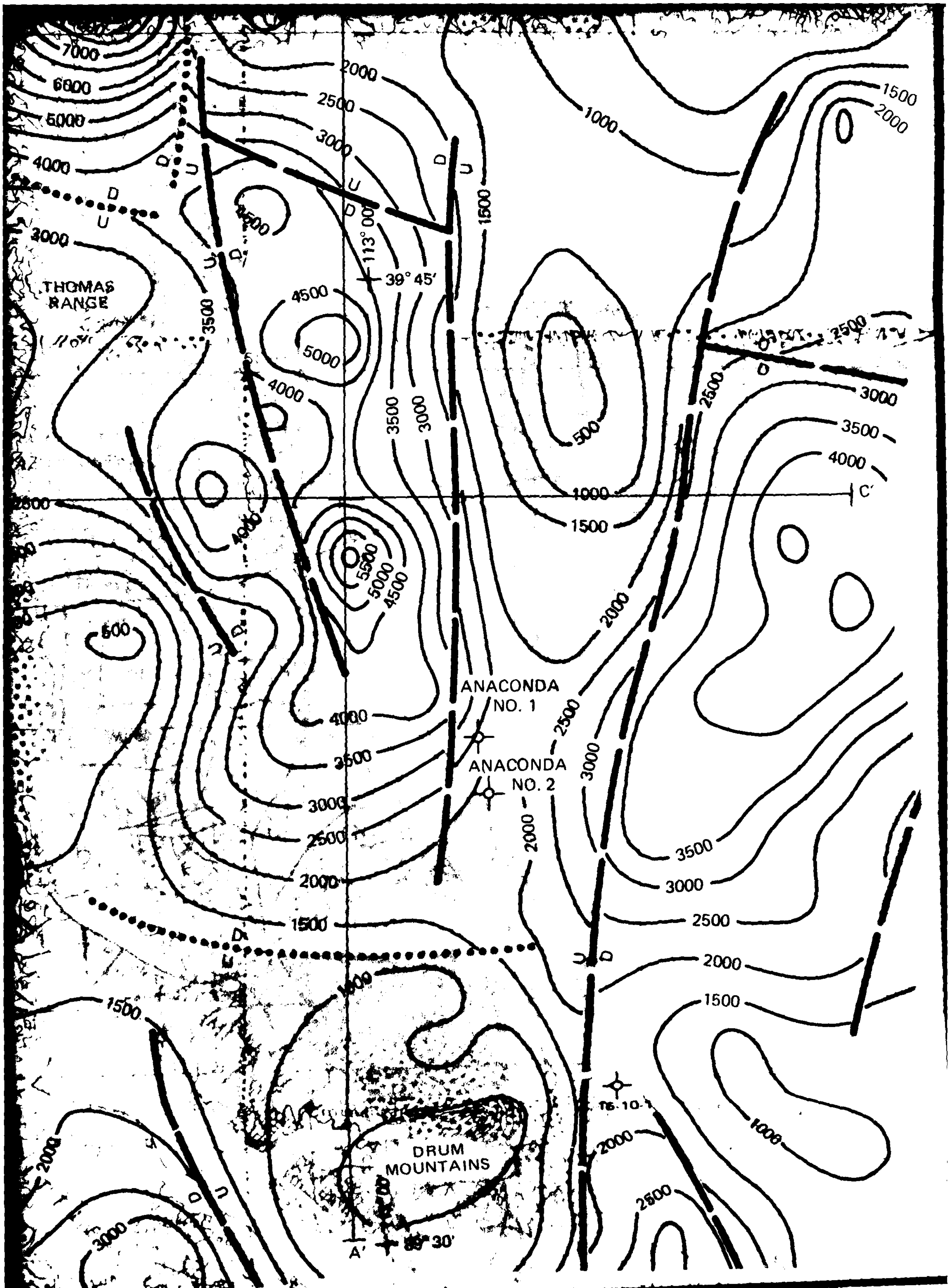
DRAWING 1

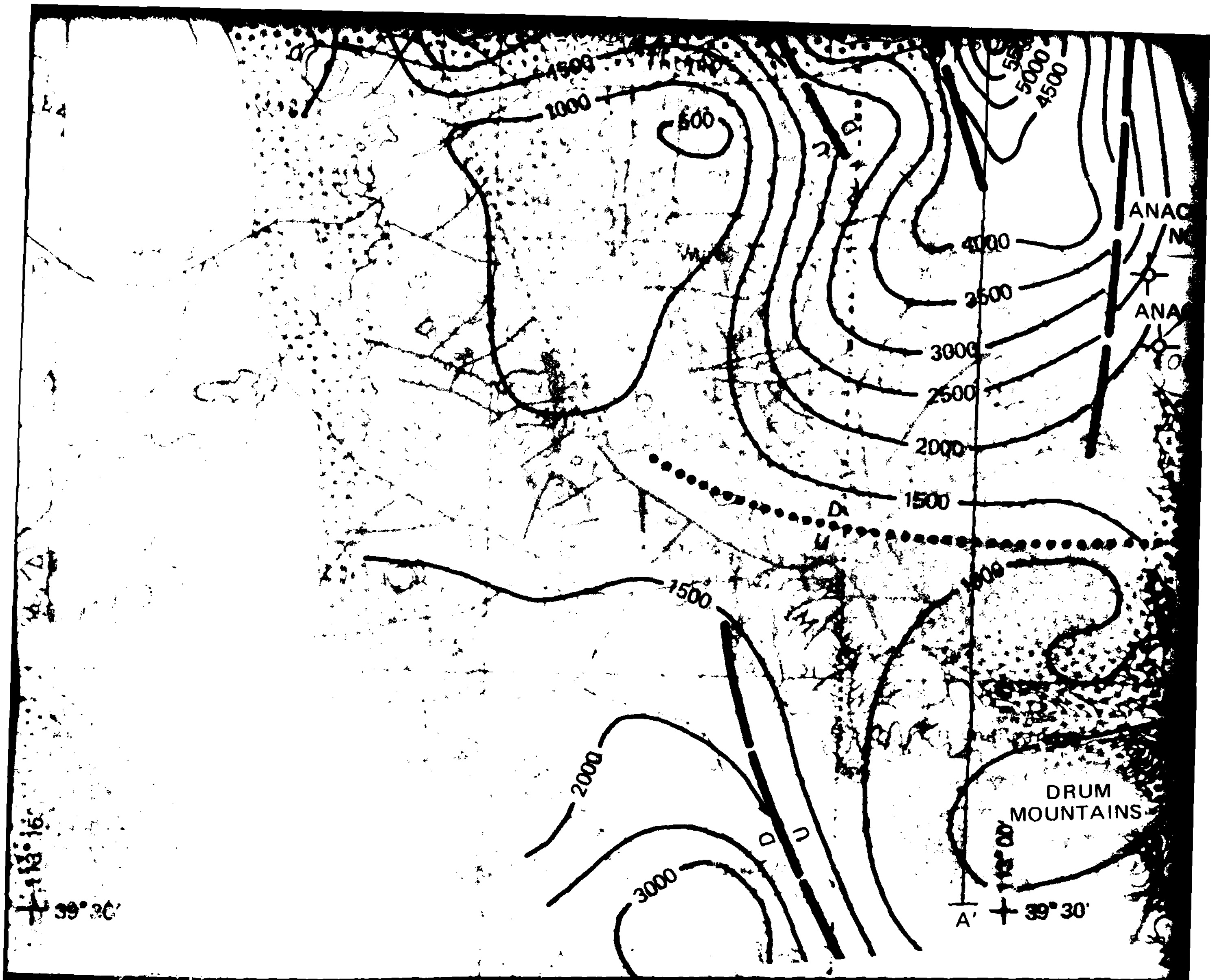


PROFILE A
113° 15'
40° 00'
500
113° 00'
40° 00'
1500
2000
3500
DUGWAY
RANGE
3000
2000
3500
PROFILE B
2500
500
1000
C-11-11
2000
U
D
U
D
500
3000
1500
1000
1500
8000
7000


PROFILE A
113° 00'
40° 00'
B'
C-10-10-1
C-11-11
SWAY
NGE
U
D
500
1000
1500
2000
2500
3000
3500
7000
8000


THOMAS RANGE
PROFILE C
DRUM MOUNTAIN
113° 15′
113° 00′
39° 45′
39° 30′
A′
6000
5000
4000
3500
3000
2500
2000
1500
1000
500
4500
5500
U
D


THOMAS RANGE
113° 00'
39° 45'
ANACONDA NO. 1
ANACONDA NO. 2
DRUM MOUNTAINS
A'
C'
TS-10
39° 30'



EXPLANATION

U / D — FAULTS INFERRED FROM GRAVITY DATA

U / D — FAULTS BASED ON LIMITED DATA

U / D — FAULTS SHOWN ON GEOLOGIC BASE MAP

ALLUVIAL MATERIAL

ROCK (ALL PATTERNS)

DEPTH CONTOUR INTERVAL = 500 FT.

DEPTH CALCULATIONS BASED ON DENSITY CONTRAST OF -0.4g/cm3

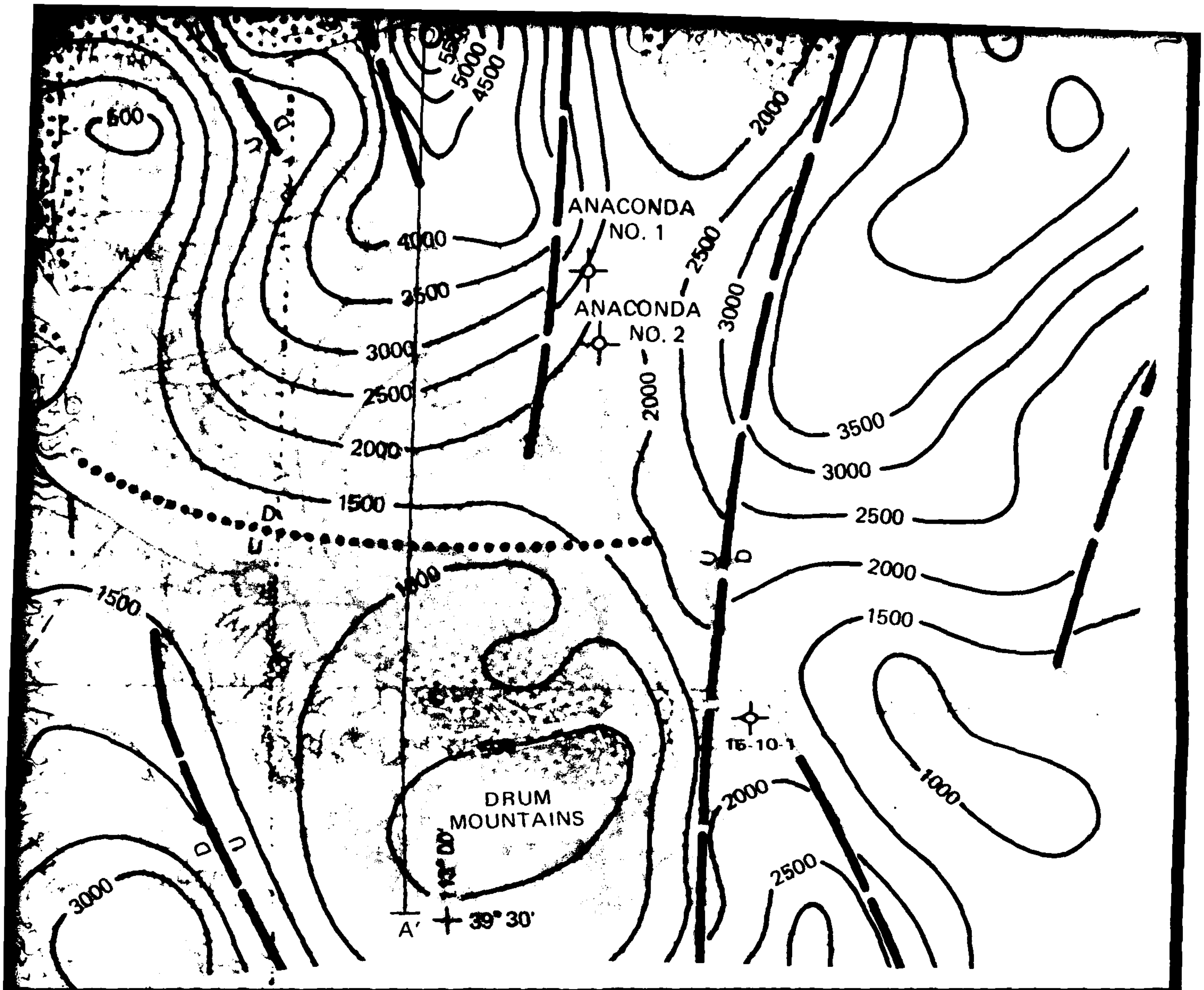
SCALE 1: 125,000

0 2 4

STATUTE MILES

0 2 4

KILOMETERS



TY DATA

A

ASE MAP

0 FT.

DEPTH CALCULATIONS BASED ON DENSITY CONTRAST OF -0.4g/cm^3

NORTH

SCALE 1: 125,000

0 2 4

STATUTE MILES

0 2 4

KILOMETERS

Ertec
The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

INTERPRETED DEPTH TO BEDROCK
DUGWAY VALLEY, UTAH

19 DEC 80
28 AUG 81 Revised

DRAWING 2